The Journal of Parasitology

Volume 4 MARCH, 1918 Number 3

STUDIES ON ILLINOIS CERCARIAE *

Ernest Carroll Faust

For two and a half years the writer has been studying the cercariae of Illinois. Material has been secured from the Rock River drainage at DeKalb and Mt. Morris, and from the Sangamon drainage at Urbana and Homer. In all cases the larvae were found in the common snails of the area, *Planorbis trivolvis, Physa gyrina* and *Goniobasis pulchella.*

The snails were dissected and the infected organs teased out in one-half normal saline solution. This solution was found to be quite satisfactory as an isotonic medium, although different species of fluke larvae vary considerably in their osmotic equilibria. In all cases in the present paper the exact course of the excretory capillaries has been traced and in six species the minute structure of the flame cells has been studied. A portion of each infected tissue has been preserved. Gilson's fluid has been used as a fixing agent. Toto mounts of the flukes and sections of the infected tissues have been studied to supplement the work on the living material. The former have been stained in a dye consisting of one part each of stock Delafield's hematoxylin and Ehrlich's acid hematoxylin in twenty-five parts of an aqueous solution of saturated ammonium alum. Sections have been stained with Delafield's hematoxylin with an eosin counterstain. The preserved material has been most valuable in observing the genital organs and the histological structure of the worm.

In a previous study the writer (1918) has shown that the infection of the mollusks of the Bitter Root Valley, Montana, varies within very limited areas but that the same larvae are found in the valley from one season to another. The Illinois cercariae are much more variable both in seasonal and locational distribution, but are on the whole more cosmopolitan species. *Cercaria trivolvis* and *C. isocotylea,* described by Cort for Urbana in 1913, were found by the writer in the Normal School pond at DeKalb in August, 1917. A furcocercous form, *Cercaria gigas,* secured from *Planorbis trivolvis* at DeKalb and

* Contributions from the Zoological Laboratory of the University of Illinois, No. 105.

from *Physa gyrina* in Pine Creek of Rock River in August, 1917, was not present in the DeKalb mollusca in October, 1917, but was found in *Planorbis trivolvis* at Urbana during this month, although not previously reported from that area. On the other hand, the finding of certain monostome cercariae (*Cercaria robusta and C. aurita*) only in a single locality does not necessarily argue for the limitation of these species to that area alone.

Habits and morphologic features of cercariae have been studied in isolated instances. Significant investigations of recent years have been made by Ssinitzin (1905, 1911), Cort (1915), and Faust (1918). Of the fifteen species described by Cort, ten were found within the state of Illinois. Of these, four were taken from Urbana, four from Chicago, and one each from Rockford and Mahomet. One species (*C. inhabilis*) was found in *Planorbis trivolvis* at Urbana and also at Lawrence, Kansas, (Cort, 1915), one (*C. douthitti*) at Chicago and Douglas Lake, Michigan, (Cort, 1917), and another (*C. diastropha*) at Chicago and Lawrence, Kansas (O'Roke, 1917). The present study includes records of two species (*C. isocotylea* Cort and *C. trivolvis* Cort) from both Urbana and DeKalb, and *C. gigas* from Urbana, DeKalb and Pine Creek.

MONOSTOME CERCARIAE

Cercaria robusta nov. spec. (Figs. 1-5)

Host: *Physa gyrina.*
Locality: Normal School pond, DeKalb.
Collected in August and October, 1917.
Parthenita: redia.

The worm for which the name *Cercaria robusta* is proposed is broadly spatulate, more or less acutely ovoid anteriad and obtusely rounded posteriad. The tail is extremely muscular, hence capable of great contraction, and is much shorter than the body. The length of an average mature specimen is 0.32 mm. and the width is 0.15 mm. The tail is about 0.15 mm. long and 0.06 mm. wide at its proximal end. There is a pair of lateral eye-spots and a single median eye on the dorsal surface just behind the pharynx. Melanoidin granules are imbedded in the hypodermal tissues over the central nervous system and extend posteriad along six lines, two dorsal, two lateral, and two ventral, marking out superficially the main posterior nerve trunks (Faust, 1918). At the postero-lateral margins of the animal are a pair of locomotor pockets, each of which is provided with a few large gland cells at its inner end (Fig. 1).

The redia averages about 2 mm. in length by about 0.4 mm. in width. Its pharynx is small but powerful. The rhabdocoel gut is longer than the cavity of the redia and is coiled forward in the region

of germ-ball proliferation. The posterior end of the redia is frequently top-shaped. The germinal epithelium lies in this posterior tip, from which the germ balls are derived. All of the rediae observed were producing cercariae. Neither lateral feet nor collar nor birth pore have been observed in the redia of this species.

The excretory system opens dorsad from an oval bladder through a small pore. Two main trunks arise from a common head just over the posterior portion of the pharynx. Each trunk receives a common external lateral halfway back from the anterior end of the system. The lateral is found to be derived from an anterior and a posterior longitudinal canal which run parallel to the main trunk. These external canals have their origin in very small capillaries. A single flame cell is probably at the head of each capillary (Fig. 1).

From an ovate pharynx 38μ in diameter the digestive tract leads back through a short esophagus to a pair of furcae which reach to the subcaudal region of the body. The furcae are not conspicuous in the living animal and are made out with difficulty in the toto mounts but may be observed in sections.

The nervous system of the animal is outlined superficially by the pattern of the melanoidin granules. The main cerebral mass is dorsal to the esophagus, forming a saddle over that organ. The pair of ventral trunks is the most conspicuous of the anterior series, while all three trunks of the posterior series, dorsals, laterals, and ventrals, are equally well developed. Transverse commissures between posterior trunks are frequent. The pair of eye-spots is lateral to the ganglion center on the dorsal side, just anterior to the junction of the dorsal and lateral nerves. These eye-spots arise from the posterior dorsal trunks. The median eye-spot is smaller and the granules are less definitely massed than those in the paired eye-spots. This cyclopean eye is immediately in front of the cerebral mass. The eye structure is similar to that of *Cercaria pellucida* (Faust, 1918).

The genital organs are clearly outlined in *Cercaria robusta*. The ovarian cell mass is skull-cap shaped; it lies just in front of the excretory bladder. A uterine duct is represented by a chain of cells which arises just anteriad to the ovary and ends in the anterior third of the worm, a short distance behind the lateral eyes. A small cell mass at its anterior end is the vagina. The two small testes are to the right and left of the excretory bladder. The vasa efferentia arise from these cell masses and, bending around the ovary, unite just anterior to this organ to form the vas deferens. The vas deferens lies to the left of the uterus and parallels it to the region of the vagina, where it ends in a small swollen mass, the cirrus. The vitelline glands are aciculate in outline. They are composed of three pairs of glands

in the outer series and four pairs and a double median gland in the inner series. The median gland is the anteriormost of the inner series and represents a fused pair. Aside from this single modification the glands are similar in position and number to those described by the writer for *Cercaria pellucida, C. konadensis,* and *C. urbanensis.*

The conspicuous structures of the living *C. robusta* are the longitudinal muscle fibers of the tail. More deeply located in this organ are six pairs of large gland cells. These correspond in grouping to the six pairs of gland cell groups in the tail of *C. konadensis* and are identical in number and structure to the six pairs of gland cells in the tail of *C. urbanensis.*

The mature *Cercaria robusta* breaks through the wall of the redia and penetrates the liver tissue of the host. It may either work its way to the free water or encyst in the liver sinuses. The movement accomplished by the coordination of oral sucker and posterior locomotor pockets is slight; most of the locomotion comes from the activity of the tail. Due to its extensive muscularization, this organ acts as a powerful whip-lash, stirring up a whirlpool eddy all around it by its violent movements. When this cercaria is set free into the water it attaches itself by the oral sucker, while a whirlpool movement of the entire worm is initiated by the tail. Encystment starts immediately. Beginning at the oral sucker it proceeds rapidly backward, limiting the size of the whirlpool as encystment continues. Finally a cyst has been formed around the entire worm, while the free tail, attached to the cyst only by a fibril, continues its characteristic movement. Then the worm within the cyst twists around and loosens its connection with the fibril. For a while the tail keeps lashing after all connection with the encysted worm has been broken, but the movement of the organ tends to become less violent and at length ceases entirely.

Cercaria aurita nov. spec. (Figs. 6-8)

Host: *Goniobasis pulchella* (Anthony).
Locality: Salt Fork of Sangamon River, Homer.
Collected: October, 1917.
Parthenita: redia.

This species is designated as *Cercaria aurita* because of the lappet processes which characterize the worm just lateral to the pair of eyespots. The animal has a length of 0.57 mm. and a width of 0.19 mm. The tail is 0.33 mm. long and 0.08 mm. wide at the base. When the animal elongates the sides are parallel and the animal is roughly rectangular, save for a blunt rostrum in front of the auricular prominences. At the postero-lateral angles are a pair of locomotor pockets, which are distinctly helpful in locomotion. When the body contracts

it becomes pear-shaped. The tail is comparatively useless. The body has a dirty grayish-brown appearance.

Cercaria aurita develops within a redia about 1.5 mm. long and 0.4 mm. in diameter. The pharynx is small and leads into a large rhabdocoel gut which extends through the body cavity about three fourths the way to the posterior end. Only a few cercariae develop at any one time within the redia. They break through the heavy wall of the redia and worm their way through the water.

The excretory tract in *C. aurita* is more primitive than that of any previously described monostome cercaria. A small oval bladder at the caudal end of the body receives two dilated trunks through a common reservoir. The trunks are very short and become reduced to the size of capillaries at the loci where they turn forward. These capillaries can be traced forward for only a short distance. This reduction in the excretory system constitutes a remarkable differentiation from the circuitous system in previously described monostome cercariae. It is further distinguished by the absence of excretory granules in the canals and trunks.

The digestive tract is prominent and easily seen in the living worm. A subspherical pharynx, 13μ in diameter, leads into a long esophagus that extends through somewhat more than the anterior third of the worm. The furcae are of a length equal to the esophagus. At their blind end they are distended, so that they appear club-shaped. The cells lining the digestive tract are large and glandular.

The nervous center of the worm is diffuse. It covers considerably more ground than that of *C. robusta*. This fact is superficially recognized by the diffuse arrangement of the melanoidin granules just beneath the basal membrane of the animal. No anterior nerve trunks are prominent; all three pairs of posterior trunks are easily made out although their transverse commissures are inconspicuous. The pair of lateral eye-spots on the dorsal side is well developed. These eyes are set out some distance from the center of the body. Their connection with the brain ganglia has not been studied.

The genital organs are most unusual in their limited extent. Except for vitelline elements they are confined to the middle third of the body. The ovary is represented by a small irregular mass of cells median in position. A short string of cells, the uterine cells, leads to a spherical mass a short distance anteriad, the vagina. The testes are slightly behind the ovary, rather irregular in appearance, and appreciably larger than the ovary. Their vasa efferentia coalesce in front of the ovary to the left of the uterus, and the common vas deferens runs forward to a spherical cirrus pouch. The vitelline glands could not be definitely made out. They are diffuse in their structure. A

small anterior portion occurs just in front of the testes. A large branch extends posteriad on the ventral side of the worm. This pattern of vitelline distribution has not been reported thus far for monostome cercariae and differs from the vitelline structure of other monostome larvae as markedly as the other features of this worm differ from those of described monostome cercariae.

The cercaria is not conspicuously active. It comes out of the mature redia as a sluggish, crawling worm. The tail is a hindrance rather than an aid in movement, for it is dragged along behind the body without any independent movement. The posterior locomotor pockets cooperate with the oral sucker in the attachment of the worm to the crawling surface. These pockets are not muscular but are provided with several large gland cells.

Encystment has not been observed, although the large number of semi-opaque cystogenous glands must function in the secretion of a cyst. The worm soon disintegrates when placed in a hypotonic medium.

ECHINOSTOME LARVAE

Cercaria chisolenata nov. spec. (Figs. 9-13)

Host: *Physa gyrina.*
Locality: Pine Creek of Rock River, near Mt. Morris.
Collected: August, 1917.
Parthenita: redia.

This echinostome cercaria is named *Cercaria chisolenata* because of the crossing of the excretory tubules at the anterior end of each lateral system. The worm is 0.3 mm. long and one-third as wide. The tail is about 0.5 mm. long and 0.09 mm. wide at the proximal end. At the anterior end the collar prominence is provided with about forty small sharp spines consisting of a series in two alternating rows on the dorsal side of the worm and extending ventrad to a region just below the anterior end of the excretory system. Each spine measures about 20μ in length. The oral sucker is 44μ in diameter. A ventral sucker of equal diameter is situated a short distance behind the middle of the body. The tail is marked by longitudinal muscle fibers, which become less conspicuous distad.

The redia is a large parthenita, 1.5 mm. long and 0.45 mm. in section across the feet. These appendages occur one-third the distance from the posterior end of the worm. A collar prominence is found near the anterior end. Just behind it on the ventral side is the conspicuous birth pore. The wall of the redia is thick. At the anterior end there is a pharynx 10μ in diameter. Behind this there is a dwarf rhabdocoel gut, barely twice the length of the pharynx. Many cercariae develop within the redia at the same time. The larvae seem to develop in batches, so that the production tends to be rhythmical.

The excretory system is typically echinostome in character. The bladder receives the pair of lateral trunks through a common chamber. These trunks are most dilated just anterior to the acetabulum, where they are filled with granules. Just behind the pharynx they narrow down to the dimensions of capillaries. At the posterior margin of the oral sucker each capillary bends abruptly outward, then backward, crossing back on itself at the junction of trunk and capillary. Here it ends in a flame cell. One flame cell is also found in the outward bend and one at the reflexing of the capillary. Three flame cells such as these at the anterior end of the system are probably found in the majority of echinostome larvae. A single median tubule in the tail cares for excretory wastes in that organ.

The digestive tract is surrounded by a very small pharynx at its anterior end. The esophagus continues to the anterior margin of the acetabulum. Here the ceca arise and continue to the caudal extremity of the worm. There are two series of mucin glands, with many members to each series. They empty through common ducts into the oral atrium of the cercaria.

The genital organs are poorly developed. An ovarian cell mass is found just anterior to the bladder; another cell mass is found at the antero-lateral margin of the acetabulum. Fine lines of vitelline follicles are traceable anteriad and posteriad.

The animal is filled with small cystogenous glands, which arise late in the development of the larva through differentiation of indifferent parenchyma cells. The worm normally decaudates and encysts in the host tissue. The cyst wall is thick and firm, providing a safe abode for the worm until a transfer of hosts is effected.

Cercaria acanthostoma nov. spec. (Figs. 14-17)

Host: *Planorbis trivolvis* and *Physa gyrina*.
Locality: Urbana.
Collected: October 29, 1917.
Parthenita: redia.

This echinostome larva resembles the typical larvae of the group in having a very muscular body and an active tail, in the possession of a collar prominence with numerous spines, and in an abundant supply of cystogenous material. The body is 0.3 mm. long and 0.12 mm. wide, while the tail is 0.44 mm. long and 0.044 mm. wide at the proximal end. The oral sucker is 58μ in diameter and the ventral sucker is 65μ in diameter. A unique character of this larva is the group of six spines inserted in a single row in the roof of the oral sucker, with points directed forward. The larva is named *Cercaria acanthostoma* because of this oral spine group. The ordinary spines around the collar number from thirty-four to thirty-eight. They are sharp-

pointed and inserted in an irregular row. The tail is crenate along the margin. Although this feature is probably due to the muscular elements of the caudal organ, the wavy outline of the organ is a constant character.

The redia is comparatively small, 0.3 mm. long and 0.058 mm. in diameter. The feet are situated three-fifths the distance from the anterior end. A collar prominence is found a little way from the oral end. The pharynx is small and leads into an inconspicuous thick-walled rhabdocoel gut. The embryos develop at the posterior end of the parthenita. They press forward as they develop.

The excretory system in the body of *Cercaria acanthostoma* consists exclusively of a bladder and delicate tubules and capillaries. The bladder is biconvex with muscular walls. The pair of main tubules enters the bladder from the extreme lateral margins. Along the course of each tubule are thirteen flame cells, eight on the inner margin of the tubule and five external to the tubule (Fig. 14). At the extreme anterior end of the excretory system the tubule reflexes and then fuses to form a delta, at each angle of which there is one flame cell. Thus the total number of flame cells along the entire course of the tubule is sixteen. This system is much more delicate than the more common echinostome type with the large lateral trunks and capillary system. The excretory system in the tail is confined to a long sac-like reservoir extending the entire length of the organ without any definite wall or lining. Near the proximal end it frequently bulges out on each side to form a lateral reservoir. No flame cells were distinguishable in the tail.

The digestive tract has a prepharynx region, a large pharynx 32μ in diameter, an esophagus extending to the anterior margin of the acetabulum, and ceca extending as far posteriad as the excretory bladder. Mucin glands are present in a biserial arrangement.

The nervous system is well developed. The six main posterior trunks are visible in the toto mounts. The pair of posterior ventrals is unusually large.

The genital cell masses consist of a pyriform ovary and a vagina along the midline just in front of the acetabulum.

The animal is filled with numerous cystogenous glands, yet encystment is slow and infrequent. When it does occur the cyst membrane which is formed is thin and tough. Through it the spines and excretory system are visible.

Cercaria trivolvis Cort

Host: *Planorbis trivolvis.*
Locality; Normal School pond, DeKalb; drainage ditch, Urbana.
Collected: November, 1916; August, 1917.
Parthenita: redia.

This species was first described by Cort in 1914 and again in 1915. The writer has been able to examine the material from the same host in the same and in a different locality. Certain points of structure not described in the original accounts have been observed.

The specimens studied by the writer were somewhat smaller than those described by Cort. They averaged in body length 0.34 mm., while Cort's specimens had an average length of 0.38 mm. Their body width was 0.11 mm. as contrasted with Cort's width measurement of 0.12 mm. Likewise the tails of the writer's specimens were about 0.44 mm. as compared with 0.5 mm. in the individuals worked over by Cort. On the other hand the oral sucker and acetabulum of the DeKalb specimens measured 50μ and 58μ, respectively, as compared with 43μ and 49μ of Cort's material. This difference in size may be entirely dependent on the degree of maturity or on nourishment, while the size of the suckers may depend largely on the degree of expansion or contraction.

In addition to the characters described by Cort, the writer has found paired right and left clumps of salivary-mucin glands filling practically the entire body from pharynx to acetabulum. Each cluster is oval and consists of a very large number of minute cells with large dilated nuclei. These gland cells are similar to those described by the writer for *Cercaria reflexa* (1918, Fig. 134). They differ, however, in arrangement and distribution.

The crevices between the body wall and the salivary-mucin glands are packed with cystogenous glands, as is also the greater portion of the posterior portion of the body. The individual gland cell is polygonal and contains several elongate cyst granules. These granules may be compared to concentrated gelatin tablets, capable of enormous swelling by water inclusion, when the stimulus for cyst formation is at hand. Then by a rapid wriggling the tail is thrown off and a thick gelatinous cyst is secreted around the larva. Through this cyst none of the organs can be definitely made out. Only the large excretory granules are apparent through the cyst membrane.

STYLET LARVAE

Cercaria stilifera nov. spec. (Figs. 18, 19)

Host: *Physa gyrina.*
Locality: Pine Creek of Rock River, near Mt. Morris.
Collected: August, 1917.
Parthenita: sporocyst.

This cercaria is large for a stylet larva, 0.32 mm. in length, 0.17 mm. wide in the region of the acetabulum, and possesses a tail 0.23 mm. long and 0.07 mm. wide at the proximal end. There is a pair of caudal pockets at the junction of body and tail, with a small number

of sharp spines directed mesad. The oral sucker is large, about 85μ in diameter, while the acetabulum, slightly posterior to the middle of the body, is only 58μ in diameter. The quill inserted in the dorsal wall of the oral sucker is a simple structure, 32μ long, and reinforced only at the base.

The cercaria develops in a sporocyst of irregular contour, about three or four times as long as the transverse diameter of the parthenita. The shape of the sporocyst is largely dependent on the movement of the cercariae within the sac. The wall of the sporocyst is extremely thin and delicate and is ruptured with the slightest pressure. Immature cercariae will not live in half-saline solution.

The excretory system in the wall of *Cercaria stilifera* consists of a bladder slightly muscular, which changes in shape from oval to squarish in surface view, a single narrow reservoir directly anterior to the bladder, a pair of lateral cornua, and two main body tubules. One of these tubules is directed posteriad, the other runs anteriad just lateral to the acetabulum and at the anterior half of the worm forms two branches, the inner one of which ends in the region of the pharynx and the outer one of which ends over the oral sucker. All of these tubules have several tributaries, each one of which originates from a pair of capillaries. At the inner end of each capillary there is a flame cell. The excretory system in the tail consists of a long awl-shaped reservoir at the proximal end immediately behind the bladder and a single median tubule with some ten tributaries, each of which arises from the junction of the two capillaries.

The digestive tract is composed of a short, narrow prepharynx, a small pharynx 17μ in diameter, a long esophagus extending almost to the acetabulum, and a pair of short ceca which barely suggest the bifurcate nature of the system. Opening into the oral atrium at the extreme sides of the large sucker are the two groups of salivary-mucin glands. There are about twelve glands in each lateral group, each gland having an individual duct to the subatrial region. Here they all empty into an enlarged portion of the system filled with granules. A single duct connects this dilation with the oral atrium.

The genital organs are represented in *C. stilifera* by a knobbed mass of cells posterior to the acetabulum, a thick cord of cells on the left of the embryo just within the limits of the acetabulum, and a thick tubule just under the anterior half of the acetabulum. All of these are joined together in the order named. In addition conspicuous masses of vitelline masses are found at the sides of the body in club-shaped aggregates extending forward to the pharynx and posteriad to the bladder. The germ cells in the posterior part of the body lie ventrad to the excretory cornua; the cell mass more anteriad lies above the ventral sucker.

The nervous system is somewhat degenerate. In the region of the pharynx is a large mass of diffuse fibers, which constitute the ganglion mass. The nerve trunks are not easily distinguished.

Cystogenous glands are found scattered through the body. They are large and relatively few in number. Their nuclei are oval to spherical, and the granules in the cytoplasm are acidophilic, as contrasted to the basophilic cystogenous granules of other species. This gland structure is probably closely correlated with the slow decaudation of the animal and infrequent encystment, and suggests that the worm gains entrance to the next host either through active swimming or the next host eating the larva while it is yet within its primary host.

Cercaria isocotylea Cort (Figs. 20-24)

Host: *Planorbis trivolvis.*
Locality: drainage ditch, Urbana, and Normal School pond, DeKalb.
Collected: 1916-1917.
Parthenita: sporocyst.

This cercaria was originally described by Cort in 1914 and again in 1915. The writer's measurements for the species are far in excess of the original description, ranging from 0.2 to 0.32 mm. for body length and 0.1 to 0.12 mm. for body width, while the oral and ventral suckers both measure about 50μ. The fact that Cort's specimens showed no cystogenous glands, together with their smaller size, suggests their immaturity. The tail in all of the specimens which the writer observed was small and not particularly active.

The stylet is described by Cort (1915: 54) as "sharp-pointed and has a thickening two-thirds of the distance from its base to its tip." The sharp, spinose portion of the stylet takes up the anterior third of the organ. The rest of the quill is set off by a nodular reinforcement on the dorsal side and is thickened dorsad toward the base (Figs. 22-24). From the base four tongue bars extend out anteriad.

At the posterior end of the worm the caudal pockets include the proximal portion of the tail. Each member of this pair is provided with a small group of spines projecting inward. The absence of these spines in Cort's description is an additional point in favor of the view that his specimens were immature. The small body spines which extend over the anterior two-thirds of the animal decrease in size from the anterior tip caudad.

Figure 20 shows the distribution of the excretory tubules in the species. At the end of each capillary is a minute flame cell. Twenty-two flame cells have been counted on each side of the body. A single unbranched tube is found in the tail.

The digestive canal has been described by Cort as undeveloped save for oral sucker, short prepharynx, and pharynx. The writer has

found a large group of gland cells in this species directly behind the pharynx. Further study has shown these cells to open into two short ceca and a miniature esophagus. These organs are at times so far dorsad that they are not in the same focus as the pharynx. The salivary-mucin glands (stylet glands of Cort) are regarded by the writer as a part of the digestive system. Their presence in echinostome and schistosome larvae, where no stylet is present, and the chemical nature of their content, make the theory of their salivary nature altogether probable. The writer has counted nine of these gland cells in each lateral group.

The genital cell masses are found dorsal to the acetabulum. On the posterior margin are found three masses, a median oval organ, the ovary, and two lateral lobed organs, the testes. Two masses dorsal to the anterior margin of the acetabulum correspond to the vagina and the cirrus sac. Stretches of vitelline glands occupy the sides of the body from the region of the pharynx to the extreme posterior margin of the body.

The cystogenous glands are similar to those of *C. stilifera,* few and vesicular. The granules are small. Decaudation occurs seldom. Encystment has been found to take place only within the host tissue. The cyst membrane is probably secreted very slowly, in contrast to that in monostomes and some echinostomes. This cyst wall is thick and gelatinous.

The topography of the various organs in these stylet cercariae, *C. stilifera* and *C. isocotylea* Cort, suggest plagiorchiine relationships. While the writer believes that the stylet *per se* is a very general character which may be found only in larval Plagiorchiiadae or may, on the other hand, be found in other related Distomata, the opening of the genital pore anterior to the acetabulum is a more specific feature of these forms to which attention is directed. The stylet larvae previously described by the writer (Faust, 1918) have been found to possess cirrus or vaginal cell masses which open into a genital atrium anterior to the acetabulum. Magath (1918) has recently shown that a stylet cercariae in *Planorbis trivolvis* at Fairport, Iowa, develops into a worm related to the Plagiorchiidae but differing from the Plagiorchiidae in having a lateral genital pore. For this he has proposed the new subfamily Lissorchiinae. Unfortunately he was unable to make out any of the genital complex in this cercariae except the ovarian cell mass, so that it can not be compared item for item with those described by the writer. However, among other things, they possess in common (1) a stylet set in the dorsal wall of the oral sucker, (2) paired mucin glands, and (3) sporocyst parthenitae. A striking difference between the excretory system of the cercaria of *Lissorchis fairporti* and the plagiorchiine cercariae is the flexing back

of the main anterior tubule in the former species and the absence of such flexing in the latter larvae. On the whole the larvae of these two families show marked relationships.

SCHISTOSOME LARVAE

Cercaria gigas nov. spec. (Figs. 25-30)

Host: *Planorbis trivolvis, Physa gyrina.*
Locality: Normal School pond, DeKalb; Pine Creek of Rock River, Mt. Morris; drainage ditch, Urbana.
Collected: August-November, 1917.
Parthenita: sporocyst.

This larva is a giant among schistosome larvae. Its body length is 0.28 mm., its width 0.09 mm.; the unforked portion of the tail is 0.32 mm. long, and the tail furci, 0.18 mm. Iturbe and Gonzalez (1917) have stated the measurement of the cercaria of *Schistosoma mansoni* to be as follows: body length, 0.1-0.13 mm.; breadth, 0.04-0.05 mm.; unforked tail, 0.14-0.15 mm.; furci, 0.04-0.05 mm. The writer's measurements on some of Iturbe's material shows a slight excess in all of these measurements. *Cercaria douthitti* (Cort, 1915) has a body length of 0.19 mm., and an unforked tail length of 0.22 mm., while the furci measure 0.089 mm. *Cercaria tuberistoma* (Faust, 1918) has a body length of 0.2 mm., and a combined tail length of 0.32 mm. O'Roke's *C. echinocauda* has a body slightly larger and a tail nearly twice as long (1917).

Cercaria gigas is characterized by a pair of pigment eyes on the dorsal side, about two-fifths the body distance from the anterior end; by a small ventral sucker, 26μ in diameter; by a long unforked portion of the tail which is muscular to an extraordinary degree, and by fluted borders to the furcae. On account of a pronounced flexure at the juncture of body and tail, the animal is more often seen on the side than on the dorsal or ventral surface. In this attitude it has a characteristic irregular appearance more easily pictured than described (Figs. 28, 29). The oral sucker sticks out anteriad like a snout. It is covered with minute spines and is invertible. The acetabulum protrudes some distance ventrad. Behind it a group of gland cells bulges ventrad. These glands are easily made out in the living animal as an oval mass of yellowish-white in the midst of a grayish background.

Often the ventral surface is streaked with pigment, especially just behind the eye-spots. Melanoidin granules are frequently distributed over both dorsal and ventral surfaces.

The unforked portion of the tail is large and powerful. Many longitudinal muscle fibers run the entire length of the organ. These are reduced in size and number in the furcae, which are thin and paddle-like with their edges directed dorsoventrad.

The sporocysts are long, irregular sacs, most usually pointed posteriad and muscular in the anteriormost portion. The walls of the sporocyst are moderately thick. The cercariae appear to develop in batches.

The excretory organs have been worked out in detail in *Cercaria gigas*. The bladder is small and oval. Two main tubes enter into it side by side at its anterior end. These reach forward to the region of the eye-spots. Along the course of each tube are ten flame cells. A main tube in the unforked portion of the tail receives a tubule from each furca. At the proximal end of the caudal organ a lateral tubule on each side flows into the main tube. At the head of each lateral tube is a flame cell. The tube splits and reunites just before it enters the bladder.

Cercaria gigas has no pharynx. Esophagus and ceca are also wanting. Very large ducts with thick walls empty into the sides of the oral sucker. These ducts are the openings of two paired groups of gland cells. The anterior of these groups consists of several gland cells centering around the acetabulum. The protoplasm of these cells is granular and the nuclei are small. The posterior group consists of many cells, small and chromophilic. All of these glands are salivary-mucin in character. Their large number is unique among Schistosomatid larvae.

The nerve tracts are well defined. Anteriad there are three main pairs of trunks. Posteriad the laterals are lacking and the dorsals soon fuse with the ventrals. The eye-spots have a direct connection with the anterior dorsal trunks.

Only one group of genital cells is found, the testes mass, just behind the acetabulum.

The cercaria does not encyst. It probably reaches its definitive host by direct method and bores its way through the tissues to the blood stream.

By gross inspection *C. gigas* is likely to be confused with *C. echinocauda*. This resemblance of the two species is pronounced, save for the longer tail stem in *C. echinocauda*. Possible confusion of these two forms warrants a discussion of their similarities and differences. The writer has been fortunate to secure material from O'Roke and has therefore been able to check up the items from the material itself. *C. echinocauda* is longer and wider; its tail length is disproportionally greater. The furcae of both species have about the same measurement. But while the furcal fins of *C. gigas* are closely fluted, those of *C. echinocauda* are flat and braced with radial thickenings so that they were mistaken by O'Roke for spines. The longitudinal muscles in the tail stem of both species are prominent, but they are coarser in *C. gigas*.

In *C. echinocauda* the furcae arise slightly lateral, with a stub of the tail stem extending slightly distad; in *C. gigas* the furcae arise from a common center in the midline. O'Roke (1917:171) mentions the flexure at the junction of body and tail of *C. echinocauda*. This flexure is much more pronounced in *C. gigas*, so that it is difficult to get a frontal mount.

C. echinocauda has no spines at the oral end of the body such as are found on *C. gigas*. The pigment eyes of *C. echinocauda* are cup-shaped, with the opening dorsolateral; the eye-spots of *C. gigas* are long, sac-shaped organs, with the long axis extending dorsoventrad. No pigmentation other than that of the eyes has been observed by the writer in *C. echinocauda*.

Internally the structural differences of the two species are pronounced. The oral pocket in *C. gigas* ends blindly; there is neither pharynx nor esophageal glands. In *C. echinocauda* there are a few attenuate esophageal glands at the base of the oral pocket. The mucin-gland ducts in both species are large and conspicuous; but while there are two structurally differentiated groups of mucin glands in *C. gigas*, with many glands in each group, there are a few large glands of only one kind in *C. echinocauda*. The latter are chromophobic. The testes cell mass in *C. gigas* is composed of several small entities immediately behind the acetabulum; in *C. echinocauda* relatively few units compose this germinal mass and the gland is a considerable distance behind the acetabulum. Moreover, other genital cell masses may be made out distinctly in the region of the acetabulum of the latter species. O'Roke has not made out the excretory tubules or flame cells in the body of *C. echinocauda* so no comparison of these organs in the two species can be made.

C. echinocauda is described as the offspring of a redia, whereas the evidence of studies on other cercariae of the furcocercous group preponderates in favor of the development of these cercariae within sporocysts. Such sporocysts are at times muscular at the anterior end, with a pouch-like structure which serves as a sucker, but in no case has a true pharynx or rhabdocoel gut been demonstrated. The material of *C. echinocauda* examined by the writer contains no parthenitae, but the general outlines of O'Roke's figures (1917, Figs. 37, 41, 47) suggest sporocysts rather than rediae. This question must be carefully checked before it is finally settled.

Cercaria minor nov. spec. (Figs. 31-33)

Host: *Physa gyrina*.
Locality: Normal School pond, DeKalb.
Collected: August, 1917.
Parthenita: sporocyst.

Cercaria minor is much smaller than *C. gigas*. The length of the oval body is 0.14 mm. and the width, 0.068 mm. The unforked tail measures 0.2 mm., which is the same length as the furcae. The tail has a transverse diameter of 40μ at the proximal end. The oral sucker opens ventrad. It is 23μ in diameter and considerably deeper. The ventral sucker is in the posterior half of the body. It is 26μ in diameter and has a small circlet of spines within its margin. A pair of non-pigmented eye-spots is found in the region posterior to the oral sucker. Large parenchyma cells are found in the unforked portion of the tail.

The sporocyst is large and irregular, measuring up to 2.1 mm. in length by 0.27 mm. in diameter. One end is slightly muscular and is used in burrowing.

The excretory system consists of an oval bladder, flattened anteriad, and a pair of main tubules which stretch anteriad to the region of the oral sucker. Each tubule gives off two biramous inner branches and a single biramous posterior twig. The tail has a single unbranched median tubule. An eyelet anastomosis occurs between the tail and the bladder.

The pharynx is represented by a few small glandular cells. Four pairs of salivary mucin glands empty into the oral sucker thru heavy ducts.

Cercaria minor has not been found to encyst. It probably reaches the definitive host as a cercaria and then metamorphoses into the adult schistosome.

In an attempt to harmonize the flame cells of furcocercariae, Cort (1918) has recognized three divisions of these larvae: (1) those characterized by absence of a pharynx, tail furcae less than half the length of the tail stem, eye-spots present; (2) human schistosome larvae; (3) those with pharynx present, tail furcae almost as long as main stem. According to this grouping, *C. gigas* falls into the first class, altho it possesses ten pairs of flame cells in the body and one pair in the tail, a larger number than is found in Cort's forms, *C. douthitti* and *C. elephantis*. While *C. minor* (Figs. 31, 32) bears some resemblance to *C. douglasi*, it is much more akin to *C. gracillima* in possessing non-pigmented eye-spots and pyriform glands in the region of the esophagus which definitely denote the transformation of the pharynx region from a muscular to a glandular organ. Moreover, *C. douglasi* is classed outside of the Schistosomatidae because it has a pharynx, while *C. gracillima* has been shown to possess a definite schistosome nervous system (Faust 1918: 54). With the broadening knowledge of schistosome larvae, it seems more reasonable to recognize a complete series of larval forms from those with a pharynx sphincter (*C. douglasi, C. emarginatae* and perhaps *C. vivax* Sonsino), thru those with a degenerate pharynx, with or without intestinal ceca (*C. gracillima,*

C. minor), thru those without any pharynx, but with well developed mucin glands (*C. gigas, C. tuberistoma, C. douthitti*), to the human schistosome cercariae. For example, *C. minor,* in lacking intestinal ceca, is more closely related to *C. douthitti* than *C. gracillima.* Yet the eye-spots in *C. minor* are not pigmented.

Until the genital cell masses of each of these larvae have been carefully studied it is useless to attempt the relationships within the groups.

Thru the courtesy of Professor Henry B. Ward, the writer has been enabled to examine specimens of *Planorbis quadelupensis* Sowerly infected with schistosome larvae sent by Dr. Juan Iturbe of Caracas, Venezuela. One vial of this material (No. 17.198 Ward collection) with the accompanying label, "rediae in state of development," was found to contain no stages in the life cycle of the schistosome larva, but instead a unique tetracotyle, for which the name *Tetracotyle iturbei* is proposed.

Tetracotyle iturbei nov. spec.

T. iturbei is a pyriform fluke, 0.42 mm. in length, 0.33 mm. in width, and 0.3 mm. in thickness. The oral sucker has a diameter of 52μ, the primitive genital pore, 42μ, and the acetabulum, 95μ. Suctorial grooves, muscular in part, are located at the sides of the ceca. The worm is unarmed and is enclosed in a thin mucoid cyst. Prepharynx is lacking; the pharynx measures 16μ in trans-section; the digestive tract forks immediately behind the pharynx. The ceca extend thru the anterior half of the body. The ovary, measuring 25μ in diameter, lies midway between the acetabulum and the posterior genital pore. Vitellaria are massed into two compact chorda, which reach cephalad as far as the primitive genital pore. The ootype, dorsal to the ovary, leads posteriad thru a short duct into a small genital pouch. Large pyriform testes, 50μ in long diameter, lie lateral and somewhat anterior to the ovary. Separate efferent ducts lead into the posterior genital atrium. Anterior to the ovary is a vagina, connected by means of a coiled tube with the anterior ventral sucker, the expanded primitive genital pore. This species yields data in support of the view that the posterior, and usually degenerate, ventral sucker of holostomes is the acetabulum of distome species.

T. iturbei is figured (Iturbe and Gonzalez, 1917; pl. 1, figs. 1-9) as the redia of *Schistosoma mansoni.* Proof that Iturbe's "redia" is a distinct species of fluke confirms the belief that rediae are not found among Schistosomatidae.

References Cited

Cort, W. W. 1915. Some North American Larval Trematodes. Ill. Biol. Monogr., 1: 447-532; 8 pl.

1918. Homologies of the Excretory System of the Forked-Tailed Cercariae. Jour. Parasit., 4: 49-57; 2 figs.

Faust, E. C. 1918. Life History Studies on Montana Trematodes. Ill. Biol. Monogr., 4: 1-120; 9 pl.

Iturbe, J. and Gonzalez, E. 1917. The Intermediate Host of *Schistosomum mansoni* in Venezuela. Natl. Acad. Med. Caracas. 7 pp., 2 pl.

Magath, T. B. 1918. The Morphology and Life History of a New Trematode Parasite, *Lissorchis fairporti*, nov. gen., et nov. spec. from the Buffalo Fish, Ictiobus. Jour. Parasit., 4: 58-69; 2 pl.

O'Roke, E. C. Larval Trematodes from Kansas Fresh-Water Snails. Kan. Univ. Sci. Bull., 10: 161-180; 7 pl.

Ssinitzin, D. Th. 1905. Distomes des poissons et des grenouilles des environs de Varsovie. Materiaux pour l'histoire naturelle des Trématodes. Mém. soc. nat. Varsovie Biol., 15: 1-210; 6 pl.

1911. La génération parthénogénétique des Trématodes et sa descendance dans les mollusques de la Mer Noire. Mém. Acad. Sci. St. Petersbourg, (8) 30: 1-127; 6 pl.

Explanation of Plates

Plate I

Cercaria robusta—Fig. 1.—Dorsal view, showing pigmentation, excretory system and longitudinal muscles of the tail. × 170. Fig. 2.—Dorsal view, showing germ glands in body and parenchyma cells in tail. × 170. Fig. 3.—Redia. × 34. Figs. 4, 5.—Stages in encystment. × 75.

Cercaria aurita—Fig. 6.—Dorsal view, showing pigmentation and excretory system. × 105. Fig. 7.—Dorsal view, showing digestive and genital organs. × 105. Fig. 8.—Redia. × 54.

Cercaria chisolenata—Fig. 9.—Dorsal view, with cystogenous glands on right of diagram. × 105. Fig. 10.—Diagram of genital cell masses. × 105. Fig. 11.—Dorsal view of collar spines. × 170. Fig. 12.—Detail of anterior tip of excretory system with three flame cells. × 370. Fig. 13.—Redia. × 54.

Plate II

Cercaria acanthostoma—Fig. 14.—Ventral view, showing excretory, digestive, and genital organs. × 170. Fig. 15.—Pattern of collar spines, dorsal view. × 333. Fig. 16.—Detail of anterior tip of excretory system. × 500. Fig. 17.—Redia. × 54.

Cercaria stilifera—Fig. 18.—Ventral view, showing excretory, digestive and genital organs. × 170. Fig. 19.—Stylet. × 370.

Cercaria isocotylea.—Fig. 20.—Ventral view, showing excretory, digestive and genital organs. × 170. Fig. 21.—Lateral view, illustrating description of spines on surface of body. × 105. Figs. 22-24.—Dorsal, lateral and ventral views of stylet. × 370.

Cercaria gigas—Fig. 25.—Dorsal view, showing eye-spots and salivary-mucin glands. × 170. Fig. 26.—Excretory system. Fig. 27.—Sporocyst. × 54. Figs. 27, 28.—Characteristic lateral views. × 54. Fig. 30.—Immature cercaria. × 54.

Cercaria minor—Fig. 31.—Ventral view, showing salivary-mucin glands in body and parenchyma cells in tail. × 170. Fig. 32.—Excretory system. × 333. Fig. 33.—Sporocyst. × 34.

PLATE I

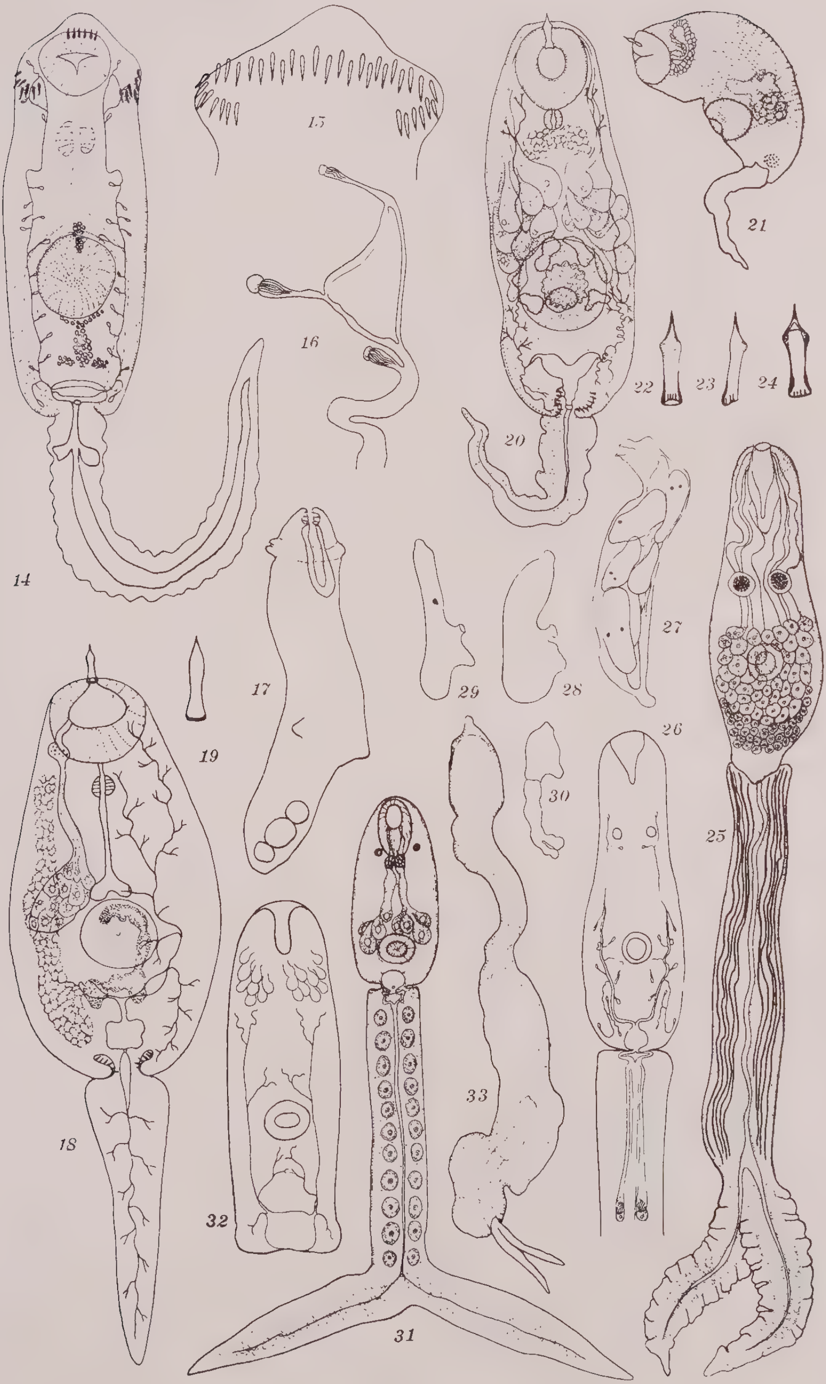


PLATE II

STUDIES ON THE SCREW WORM FLY, *CHRYSOMYIA MACELLARIA* FABRICIUS IN PANAMA *

L. H. Dunn

Entomologist, Board of Health Laboratory, Ancon, Canal Zone

Throughout the Canal Zone and the Republic of Panama the screw worm fly may be found in great abundance and owing to its dangerous habit of depositing its eggs in living as well as on dead tissues of man and animals, is of considerable importance economically. The number of eggs deposited in one batch by each individual fly seems to vary considerably, but when all circumstances are favorable averages 190. Of a number of batches counted by the writer the minimum deposited at one time was 48 and the maximum 287.

When ovipositing in inanimate animal substances the females seem to evince a desire to lay their egg masses all together in a heap. If a number of females are confined in a jar containing a piece of meat and one deposits her eggs, either on or near the meat, the others then oviposit either next to or on top of the mass of eggs deposited by the first female.

The eggs of a single female are laid in an irregular mass or pile, usually being placed so they overlap or rest partly on top of each other after the manner of shingles. The time required for the eggs to hatch seems to be subject to some variation. The shortest time observed was 11 hours, the longest 23 and the average about 14 hours.

Surrounding conditions seems to exert but slight influence on this incubation period as moisture and temperature are, in a certain sense, always the same in Panama. The surrounding material whether in dead carcasses, decaying vegetable tissue, or live animal tissue, is in nearly all cases of a moist nature, at least sufficiently so to keep the eggs moist. Changes in the temperature of Panama are so slight that one may disregard their influence on the incubation period of eggs deposited on inanimate material. When eggs are deposited in animate objects the body heat may tend to shorten the incubation period considerably but there has been no opportunity to verify this opinion as no tests have been made with living animals. The variations seem to be primarily due to scarcity or abundance of suitable material in which to deposit the eggs and the consequent differences in the age of the embryos at the time the eggs are deposited.

* From a paper read before the Medical Association of the Isthmian Canal Zone July 20, 1917, to appear in full in an early number of the Proceedings of that Association; its distribution in that form will be limited and it contains much of interest to the parasitologist. W. A. R.

The growth of the larvae is very rapid, approximately 2 mm. a day until they become mature on the fifth or sixth day. There is then a period of about 24 hours during which the larvae feed but little and after which they leave the material on which they have been feeding to seek a suitable place to pass the pupal period. Under ordinary conditions this occupies a period of from four to five days but may be shortened to three days or extended to ten. Among the emerging adults there is little disparity between the sexes. In one lot of 450 flies, 42% were females and 58% were males. Sex did not exert any appreciable influence on the length of the pupal period.

The adult flies exist on fluids or semi-fluids in material that can be reduced to a semi-liquid food. This is generally found in garbage cans, refuse heaps, or other places of like nature near habitations, and in decaying animal and plant life or other odoriferous substances in the woods or jungle away from habitations. In the Canal Zone specimens have been captured while feeding on the syrup-like fluid in the decaying flower bracts of the Heliconia plants.

The females appear to prefer the late afternoon or evening to deposit their eggs. This raises the question whether or not they remain active after nightfall and fly about in search of places to ovipost. Most varieties of flies became inactive at nightfall, but I have known this species to deposit its eggs during the night while in captivity, and when gravid females are captured and placed in breeding jars, they will oviposit much more readily if the jar is covered with a dark cloth than if it is left uncovered.

In Panama this fly seems to be entirely impartial in its choice of environments. It shows a preference in its breeding places in so far as the material is concerned, but if suitable places are found in town and villages, the fly will be found there as well as in the jungle. In towns they may be found flying with an angry hum about decaying material left exposed, or around a corral containing cattle. The females are very active and always on the alert, searching for either food or a place to deposit their eggs. In the jungle they are quickly attracted by any animal, probably by its odor, but perhaps also by its motion. While passing along a trail they sometimes follow and fly around one's head with a vigorous buzzing noise, undoubtedly in search of a place to deposit their eggs.

ATTACKS ON MAN

It is safe to say that throughout the Isthmus of Panama this fly through the agency of its larvae causes a greater amount of damage and suffering to cattle, horses and other animals, than does any other dipterous pest found there, and if one excepts the disease-bearing mosquitoes the same also applies to man as well as animals.

Eggs are deposited in the human nasal and aural cavities and in other natural openings of the body as well as in every exposed wound, ulcer, and bleeding surface. This infestation usually occurs while the victim is sleeping in some exposed place. The nasal cavity is a favorite place of attack and also the most dangerous one for the victim. In these cases the person attacked generally has recently had an attack of nose-bleed with a clot of blood remaining in the nose, or has a nasal catarrh with an offensive discharge, or a foul-smelling breath.

Sleeping in the woods or jungle, and occasionally even in unscreened houses is fraught with danger. The odor of an offensive discharge or the scent of fresh blood is very perceptible to the strong sense of smell of this fly, and if any are in the vicinity they are soon attracted to the sleeper and proceed to deposit their eggs in his nostrils. As soon as the eggs hatch and the young screw worms emerge, they begin to migrate farther into the nostrils. They tear into the mucous membranes lining the nasal cavity, feeding on the blood and serum oozing from the small wounds caused by the chitinous head hooks. They soon penetrate into the sinuses of the nasal fossae, darker and moister regions. As the young maggots begin to feed they grow rapidly as they are in ideal surroundings for growth, namely plenty of liquid food, warm temperature, and a constant supply of fresh air. Under these conditions they are very active, soon devouring the membranes lining the nasal fossae and burrowing into the surrounding muscles and cartilages. The unfortunate victim suffers at first intense irritation which soon changes to very severe pain so that he undergoes considerable suffering.

In cases of nasal myiasis one often finds a history of a nose bleed at the beginning of the disease. This leads to the conjecture that the hemorrhage precedes the infestation and that the smell of blood attracts the fly which deposits her eggs at the first opportunity easily given if the individual lies down to sleep. In the opinion of the writer this is undoubtedly the manner in which infestation takes place in a great many cases, but it is very difficult to determine this point positively. Being attracted by an odoriferous catarrhal condition the flies may also deposit their eggs in the nostrils of a person having such a condition while he is asleep. The newly hatched larvae on burrowing into the membranes may tear open small veins and capillaries and cause hemorrhage, but in such a case the laceration of the blood vessels would be so gradual that the nose bleed would be but an oozing of blood mixed with serous fluid, and unlike an ordinary case of epistaxis.

Physicians coming in contact with nasal myiasis for the first time may often be at a loss for a diagnosis of the condition, and especially in a case where the worms are in the upper cavities or have burrowed so deeply into the tissues that they are not readily discernible. This

may not be until the larvae begin either to emerge from the patient's nose or to enter the mouth through the pharynx and to be expectorated. In tropical America a bloody, foul smelling, offensive discharge from the nostrils should arouse a suspicion that screw worms might be present.

A number of cases of human myiasis caused by *C. macellaria* have been reported from different parts of the United States, and Central and South America, and in but a few instances does the patient recall being attacked by flies. In a few cases it has been claimed that a fly had dashed into the nose while the victim was awake and moving about, but he was unaware that any eggs had been deposited. It is more than likely that in such cases a fly dashing at the nostrils was simply a coincidence and merely recalled on acount of the worms being present in the nose and the patient being at a loss to account for the presence. The chances are a thousand to one that the fly he recalled, or imagined as trying to dash into the nose was innocent of depositing the eggs, which were probably those of another fly, deposited without knowledge of the person attacked. An imaginative patient could readily recall at any time the annoyance caused by a fly buzzing about his head.

A mass of 100 eggs of this fly measures about 4 mm. in diameter, or about the size of a small pea. Such being the case it seems highly improbable to any one who has made many observations on this fly and who is familiar with their egg laying habits and the size of the egg mass, that any normal person and especially any one having the nasal passages clear and being in the habit of breathing through the nostrils, could have a mass of eggs in the nostrils until they hatch without being aware of the presence of a foreign substance, except under certain conditions.

It is the opinion of the writer that infestation takes place in the nose under one of the following conditions: 1. A person goes to sleep in the late afternoon or early evening, and sleeps all night; the eggs are deposited in the early part of the evening and have a chance to hatch so that the young larvae ascend into the nostrils before the sleeper awakes in the morning. 2. During the day time a person who is intoxicated may lie down out of doors and remain in a drunken stupor for a number of hours, giving the larvae opportunity to hatch either while he is still in the stupor, or while the after effects of the intoxication on his head prevent the discovery of the eggs in his nose until after they have hatched. 3. An individual that has just had an attack of nose bleed and had a blood clot still remaining in the nares might very readily have a mass of eggs in the clot without being aware of their presence until after they had hatched. 4. A person afflicted with leprosy or any other disease causing anesthesia of the nasal

mucous membranes could very easily have eggs deposited in the nose while asleep and not know of their presence until they had hatched and the larvae had burrowed into sound tissue and caused pain. In cases where several hundred screw worms are found in the nose it is very evident that the victim was asleep, and the fly was unmolested for some time while depositing the eggs.

The writer has been informed that in the interior and remoter parts of Panama, it is not uncommon to find among the natives or Indians cases of nasal myiasis which terminate fatally. A large percentage of these cases have become infested after the individual had visited some town or village, drank heavily, and started for his home in a state of intoxication. The patient has a number of miles to travel on foot, horseback, or in a cayuca. The liquor making him drowsy he lay down in some shady place to sleep, and having a bloody surface in the nose or suffering from a nasal discharge he became a good subject for infestation.

Screw worm infestation is frequently in the ears, although records seem to show aural myiasis is somewhat less frequent than nasal myiasis. Babies and other persons that are somewhat defenseless, and whose ears are discharging, or are neglected and allowed to become dirty and emit an odor, even though sometimes very slight, are the ones that usually become infested. In these cases if the worms are not detected at an early stage they penetrate into the middle and inner ear, causing considerable suffering and sometimes death.

Infestation of the genitalia takes place occasionally. This usually happens among naked children, though it sometimes occurs in old people, who through senility or other causes, do not keep themselves properly protected with clothing at all times. All open wounds, sores, ulcers, and abrasions of the skin in man if left unprotected by dressings or clothing also prove to be good places for the female of this fly to deposit her eggs. The smell of blood in a fresh wound as well as any suppurating sore serves as an attraction. As a matter of fact, this species seems to be greatly attracted by any animal odor and will deposit its eggs in most any place on either man or animal whenever a favorable opportunity presents itself.

A normal umbilicus is sometimes selected as a place for oviposition. A case of umbilical myiasis was encountered at the Ancon dispensary on January 10, 1916, when a white Spanish laborer came to complain of soreness in the umbilicus. Dr. S. L. Van Valsah, formerly of this hospital, examined the man and found in the umbilicus three fly larvae which he extracted. He was kind enough to send both the larvae and patient to the laboratory for me to examine. The patient was a clean, well kept man of middle age, and although the umbilicus was quite deep and nearly closed there was no apparent odor emanating. It had

a very red and irritated appearance and the man complained it was very sore and tender to touch, but the skin was not pierced and there was no blood showing. He stated that for several weeks he had been one of a gang of men engaged in cutting grass and bushes, and clearing land at Corozal. He had finished with this work on December 31, 1915. The following day, January 1, 1916, he felt something "molesting" him, as he termed it, in the umbilicus which gradually increased until the soreness caused him to visit the dispensary on January 10.

This man claimed that he lived in a screened house at Balboa; that he always wore a shirt while working; that he had not lain down to sleep during the day time; and also that he had never observed any fly alighting on him anywhere near the umbilicus, so that it remains a mystery as to when he became infested. Very probably he had either laid down and fallen asleep during the day time and did not care to acknowledge it, or a fly had entered his quarters either through a hole in the screening, or through a door which had been left open. Many of the Spanish laborers while at work wear but a light undershirt with no overshirt. This might have been torn or loose enough to allow a fly to reach the umbilicus while he was asleep. At any rate, infestation had taken place without his knowledge and undoubtedly while he was asleep.

Two of these larvae were rather small, but the third one was large and mature. They were bred out and proved to be *C. macellaria*. Evidently these larvae had been in the umbilicus for nine days, living on the exfoliated skin debris, perspiration, and such serum as possibly exuded from the tiny scratches made by the head hooks of the larvae. In this case there was no blood, or suppurating or raw surface to attract the fly. The only attraction was probably the odor of living flesh, or some odor that might have been thrown off from the umbilicus when the man while working became warm and perspiring. It is the opinion of the writer that an annual survey of all the towns and settlements throughout the Republic of Panama would disclose a surprising number of deaths due to screw worm infestation, either as a principal or contributory cause.

ATTACKS ON ANIMALS

Besides man nearly all kinds of domestic animals, and some of the wild animals are subject to attacks from this fly. It has been recently discovered that this fly will deposit its eggs in the nostrils of perfectly healthy dogs. Dr. H. C. Clark, pathologist at this laboratory, informed me that he had examined a dog a few months previous that had been infested in this manner. This dog was a male deer hound and one of a pack owned by a hunting club at Ancon. The pack had

been taken to the Province of Chiriqui on a hunting trip and the dog became infested in the nostrils while there. After doing considerable damage by eating through the tissues into the mouth, the maggots were all removed and the dog saved.

When brought back to Ancon, a few weeks later, the dog was brought to the laboratory and examined by Dr. Clark. The worms had caused a loss of bones in the upper right half of the mouth and nose, loss of teeth in the upper right jaw, and partial or complete loss of smell. The health was recovered in other respects, The dog was of no further use in hunting, as the destruction of the sense of smell incapacitated him for following a trail. The screw worm may be classed as an important enemy of dogs on the Isthmus, not alone owing to the actual amount of tissue it destroys, but also on account of giving a favorable field for micrococcus infection which often follows attacks of myiasis and causes death.

Cats lick and clean all wounds that they can reach so persistently that larvae seldom have any chance to live in a lesion, but one cat has been observed that had two full grown screw worms in an open wound at the base of the skull just back of the ears. In this location it was impossible for the cat either to lick them with her tongue, or to remove them by rubbing with her paws. These worms have also been found in neglected spur wounds on fighting cocks. It is not known whether this is a common occurrence or not but one case was noted personally in the city of Panama.

Three tame deer that were kept in a yard at the laboratory a short time ago all became infested from very insignificant wounds. One male had worms in a wound near the base of the horns which in the beginning was nothing but a small place where the skin had become chafed and broken by a rope tied about the horns. The second one become infested in a wound on the hind leg near the knee which was originally a small nail wound. The outer opening in the skin remained very small, but the cavity beneath was quite deep, reached to the bone and followed along side of it for a short distance down the leg. Fifty-two larvae were removed from this wound. The third deer acquired maggots in a small wound on the nose caused by running against the fence.

EMERGENCE OF LARVAE WHEN BURIED IN THE GROUND

It is manifest that when a horse, cow, steer, or other animal dies and is left for a few hours before being disposed of, many eggs of this fly are deposited in the mouth, nose and other cavities. If burial is the method of disposal and is delayed beyond the time required for the eggs to hatch, the cavities will contain many young larvae that

will be buried with the cadaver. Even if the eggs are not hatched before burial their hatching is delayed but little, and the young larvae emerge as readily under the ground as on the surface.

After a cadaver is interred decomposition takes place somewhat more slowly than when it is exposed to the open air. This delay combined with the fact that the ground absorbs a large amount of the gases thrown off enables the larvae to live in the cavities, and to find a sufficient supply of oxygen to insure their reaching maturity.

In order to investigate the depth at which the larvae may be buried and still live, develop and emerge from the surface as adults, seventy-five larvae about half matured were placed in a wide-mouth bottle containing a piece of fresh meat. The bottle was left unstoppered and placed at the bottom of a box about five inches square and three feet deep. A mixture of clay and sand was placed on top of the bottle to the depth of two and a half feet. This earth was tamped to make it as compact as undisturbed ground would be. A wire screen cover was then fastened securely over the open end of the box. The box with the closed end containing the larvae downward was set in the ground, the earth was replaced around the box and packed tightly to equalize inside temperature, moisture, etc., a few inches of the box and the screen cover projected above the surface of the ground, and was inspected each day thereafter for adult flies.

Ten days following the burial of the larvae the first adult flies were found in the cage. They continued to emerge up to the fourteenth day, and a total of forty-two emerged during the four days. This shows that 56 per cent. of the buried larvae lived to complete their metamorphosis and reach the open air as adults. Eighty-four per cent. of the number that emerged were females.

When the carcass of a dead animal is buried, it is seldom that it is covered with more than two and a half feet of earth; while 56 per cent. of the larvae buried with the carcass emerge at this depth, the percentage that emerges when the carcass is buried at lesser depth must be proportionately greater.

TRANSMISSION OF DISEASE BY THE FLY

Up to the present no positive proof has been found that will serve to incriminate the species as a disease-transmitting agent. However, work along this line is advisable, especially as regards the transmission of anthrax among cattle. When an animal dies of anthrax a thin blood stained fluid is usually sprayed from the mouth and nostrils. If in a pasture, the animal is generally stretched out on the ground, and when dying the ground in front of the head is sprayed with this liquid and the face around the nose and mouth covered with it. Cattle

dying of anthrax seem to bloat very quickly and in some cases the odor of decomposition is noticeable shortly after death even while the bloody spray is still wet on the muzzle of the animal, or on the grass in front of it.

In localities where the screw worm flies are numerous they are attracted to an animal succumbing to anthrax very soon after death has occurred. In such cases they are found either feeding on the discharged fluids on the ground or face of the animal, or are busy depositing their eggs about the mouth, nose, anus, vulva or other place where there is sufficient discharge to produce a moist surface.

In Panama the buzzards locate the body of an animal soon after death and after a few of these scavengers start feeding on a carcass it presents even better opportunities for the flies.

In April, 1916, the writer viewed the carcasses of three steers that had died of anthrax in a pasture near Colon. They had been dead only a few hours but had begun to bloat and a strong odor of decomposition was emanating from them. A veritable swarm of screw worm flies was feeding and ovipositing on each carcass, although they were nearly a mile apart. When these flies either feed or oviposit on a carcass the feet and proboscis must necessarily become contaminated and in my opinion they are capable of infecting any animal that they may visit shortly after; that is, providing the animal happens to have a fresh brand mark that is unhealed, cuts from barbed wire, horn wounds, or any skin abrasions.

It is claimed that the anthrax bacilli will survive in the ground for several years and that even if all cattle are removed from a pasture that has become badly infected and it is left empty for several years, the infection may be still in the ground. If cattle are pastured over this ground even after five or six years a fresh epidemic is liable to break out. If the *Bacillus anthracis* is able to survive the rays of the tropical sun in the soil of Panama for several years it is certainly able to live on the feet and proboscis of the screw worm fly for a few hours or even days It is plausible to believe that this fly may be one of the principal carrying agents in tropical and subtropical countries and it is hoped that observations may be carried out to test this theory of transmission.

BREEDING OUT LARVAE FROM CASES OF MYIASIS

Although the screw worm fly is the principal culprit it is known that other flies have the habit of depositing their eggs or living larvae in open wounds or on exposed parts of the body. It is to be deplored that in a great many cases of human myiasis the larvæ are never identified or bred out to ascertain whether they are really *C. macellaria* or some other variety of fly. It is therefore suggested to physicians

called to attend a case of myiasis, that before washing the wound with any solution they remove specimens of the larvae from the lesion by means of forceps, with as little injury as possible, and place them in a glass jar containing damp sand and a piece of meat or decayed vegetable. The jar should be covered with a piece of muslin drawn tightly over the top and fastened with string or a broad elastic band. Beyond noting if more food is needed nothing else is necessary except to watch for the emergence of the adult flies. When they appear a few drops of chloroform may be poured on the muslin top which should then be covered with a piece of pasteboard or other flat object to retain the chloroform vapor in the jar. After exposure to this for a few minutes the flies may be removed and examined.

If this procedure could be carried out in all cases of cutaneous myiasis it might incriminate other flies on the Canal Zone, hitherto unsuspected, of having the same propensity for breeding in living flesh. *C. macellaria* is easily the principal offender in cases of nasal myiasis.

PREVENTIVE AND CONTROL MEASURES

Tests which are detailed in the complete paper were made with different drugs and chemicals to determine their respective lethal effects on the screw worm. From twenty to twenty-five worms, all of which were approximately mature, were used in testing each substance. The agents giving the most satisfactory lethal action were fat solvents which readily penetrated and dissolved the fatty tissue of the larvae.

Owing both to the great diversity of the breeding habits of this fly, and to the peculiar conditions existing in Panama, but little can be said in regard to its control. In caring for animals with infested wounds all open lesions may be sprayed with chloroform or carbon tetrachlorid to remove the maggots. Both of these have proved efficacious.

Carbon tetrachlorid is as fatal to the maggots as chloroform if not more so, it is equal in penetrating power, does not evaporate any more readily, produces no more irritation to the tissues, does not retard healing any longer, and is much cheaper. Carbon tetrachlorid does not attract the flies by its odor as the carbon bisulphide is said to do, and it also lacks the inflammability of the latter.

In deep punctured wounds it may be best to spray with glycerine first to cause the maggots to become active and approach the outer opening of the wound. They may then be sprayed with carbon tetrachlorid to destroy them. If one of the lethal fat solvents is injected in a deep wound in an undiluted state the larvae are apt to be killed before they are able to leave the wound, and remain as a foreign body causing suppuration. After a wound on an animal has been

cleaned of all screw worms it should be dressed with one of the repellent agents to keep the flies from depositing more eggs in the wound. Pine tar is a good repellent.

An excellent protective dressing may also be made by mixing equal parts of beeswax, fish oil, and carbon tetrachlorid, working in enough vaselin to give it the proper consistency. If all animal wounds, both those which are fresh and those from which the screw worms have been removed, are painted with this mixture it will prevent the flies from depositing their eggs and save the cattle from damage as well as reduce the number of the flies.

All fresh meat should be screened to prevent it from becoming blown and if necessary the screen may be reinforced with cheese cloth.

Lastly, all parties camping in the jungle should sleep under mosquito netting. This especially is necessary for persons having a nose bleed or catarrhal condition. And it should be remembered that it is of more vital importance to use the mosquito netting while taking siestas during the day than at night, as far as protection against this fly is concerned. A number of people who would use a netting at night as a protection against mosquitoes would scorn to sleep under it during the day time, but it must be remembered that the screw worm fly apparently deposits her eggs during the daylight hours, or at least before it gets very dark.

METHODS OF ASEXUAL AND PARTHENOGENETIC REPRODUCTION IN CESTODES

T. Southwell
Director of Fisheries, Bengal, and Bihar & Orissa

AND

Baini Prashad
Superintendent of Fisheries

In the following paper we propose summarizing the various facts, known at present, regarding the different methods by which the Cestoda reproduce themselves, asexually and parthenogenetically. The formation of secondary bladders in the parent cysticercoid, like what occurs in some of the common forms such as Coenurus, Echinococcus and Polycercus, is, of course, quite well known, but though some of the more uncommon types have been described carefully, they have never received that attention which they merit. Recently, two special types of budding in larval cestodes have been described, one by Ijima (1905) and the other by Beddard (1912). These instances, together with a new case of parthenogenetic reproduction, in what we believe to be a new and adult worm recorded by us (1917), suggested the desirability of reviewing those reproductive methods (other than sexual) known to occur in the Cestoda both in the larval and adult stages. We propose to discuss each case separately, beginning with larval forms in which such reproduction takes place.

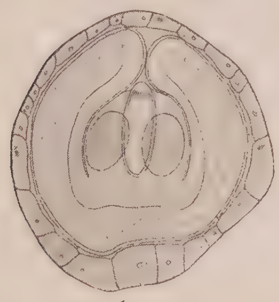
TYPE A.—WITH INTERNAL BUDDING BY PROLIFERATION

1. Monocercus Villot.—In this genus a very primitive condition in the pro-scolex, or blastogen, gives rise to a single caudal bladder by a typical method of endogenous budding.

This is to be seen clearly in the species *Monocercus* (*Cysticercus*) *arionis* (Siebold). Villot describes an original connection between the posterior part of the caudal vesicle of the cysticercoid and the cyst, in the form of "une sorte d'ombilic ou de depression infundibuliforme." In *M. didymogastris* Hill no original connection can be seen in the fully formed cysticercoid (Fig. 1). This certainly appears to be an advance on the condition in *M. arionis* described by Villot and leads to the condition in Polycercus which will now be considered.

2. Polycercus Villot.—The generic name Polycercus was proposed by Villot in 1883 for a cystic worm described in 1868 by Metchnikov. The species *P. niloticus* was so named by Willey (1907) because the

adult tapeworm stage of Metchnikov's larva is now known to be *Taenia nilotica* Krabbe, 1869, which is parasitic in *Cursorius europeus*. In its mature condition this species consists of a thin skinned bladder which contains a varying number (up to 13) of small cysticercoids of about 0.5 mm. in diameter. Although the latter lie quite free in the interior of the cyst and possess like the ordinary cysticercoids the distinctive caudal bladder, they are of very unusual origin, inasmuch as instead of developing directly from the six-hooked embryos, they arise by proliferation of the internal wall of the surrounding bladder (Fig. 2). The bladder is thus the brood capsule of the enclosed cysticercoids and corresponds in some respects to the brood capsule of the Echinococcus, or perhaps to a Coenurus bladder, and like these is undoubtedly to be referred to the six-hooked embryo. The first



1

A B

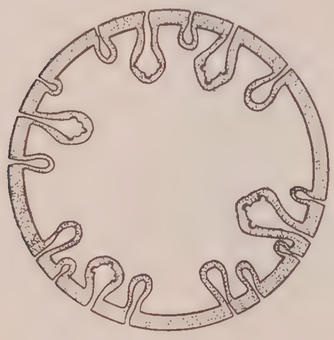
2

Fig. 1.—Cyst of *Monocercus didymogastris*. (After Hill.)
Fig. 2.—Cyst of *Polycercus niloticus*. (Altered from Benham.)

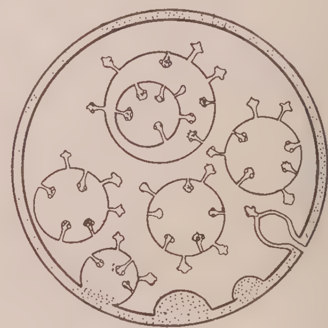
developmental stage observed by Metchnikov appeared as a solid ball of about 0.08 mm. with an unusually thick cuticular envelope and cellular contents. The latter subsequently became clear on attaining a diameter of 0.14 mm. when the embryo lies on the inner surface of the cuticula in the form of a cellular layer. Soon the buds begin to form and at that exclusively from the cellular wall which becomes thicker at certain spots and sends little projections into the inner cavity. Although at first flat and connected by their broad bases with the cellular wall, the protuberances, as they grow larger, detach themselves from the subsequent layer. This separation is facilitated by the development of a hollow space in the interior of the basal portion, so that after a time the bud is only connected with the mother-bladder by a thin filament. Finally, this connection is destroyed and the bud thus becomes an oval body lying freely in the interior, so that at the end of its development the worm has exactly the same position as we formerly observed in *Cysticercus* (*Monocercus*) *arionis*.

From the above it will be seen that this type of budding is only an advance on the type described for Monocercus, in that more than one area of proliferation arises on the inner wall. These areas then hollow out and are later on detached when they become free in the central cavity of the parent cyst where each develops a head and becomes a *cysticercoid*. Haswell and Hill's type of Polycercus differs from the preceding type and will be dealt with later on.

3. Coenurus Rud.—In *Coenurus cerebralis* (Batsch) Rud. the stage is still further advanced than what occurs in Polycercus in that numerous scolices arise within the cavity of the parent cyst by a process of invagination of the cyst wall; but these never become detached from the cyst wall (Fig. 3).



3



4

Fig. 3.—Cyst of *Coenurus cerebralis*. (From Benham.)
Fig. 4.—Cyst of *Echinococcus* sp. (From Benham.)

4. Echinococcus Rud.—Here the condition appears to be very much more advanced, combining some of the features seen in Polycercus and Coenurus. In the cyst of this genus secondary bladders are formed as proliferations from the inner wall of the parent cyst, exactly as in Polycercus, but instead of a single head or scolex being developed in each, a large number of scolices arise in each of these secondary cysts (Fig. 4). By a continuation of the same process, tertiary bladders may also be formed from the wall of the secondary bladders, whilst still enclosed in the parent cyst.

TYPE B.—WITH INTERNAL BUDDING IN AN UNKNOWN WAY

We may now consider two distinct types of endogenous budding in cysticercoids believed to be the larval stages of *Tetrarhynchus unionifactor* Herdman and Hornell, occurring in *Placuna placenta* Linn. and *Margaritifera vulgaris* Schum. (*Avicula fucata* Gould). One of these types was first recorded by Hornell (1906) in *Placuna placenta*.

It was recorded subsequently by Willey (1907) and the cysticercus was provisionally named Merocercus. Hornell described the formation of a single secondary cyst within the parent form, but Willey later on, working on the same form from the same locality, not only confirmed Hornell's discovery, but added that the endogenously produced larvae were a very common feature of this form and that multiple formation of endogens within a single cyst was likewise common. As many as twenty secondary cysts were seen in one parent cyst (Fig. 5). Monogenetic cysts were also observed by Willey (Fig. 6), but the multiple type of proliferation was the rule. This suggests that the monogen type may only be a stage in the development of the multiple type of cysts. This multiple endogeny, however, differs from what was recorded later on (Fig. 7) by one of us (Southwell, 1910) in that the parasite from *M. vulgaris* shows simple endogeny. Multiple

6 5 7

Fig. 5.—Cyst of Merocercus with a large number of daughter cysts. (After Willey.)

Fig. 6.—Monogen cyst of *Tetrarhynchus unionifactor* (?) Monocercus. (After Willey.)

Fig. 7.—Cyst of *Tetrarhynchus unionifactor*. (After Southwell.)

endogeny was never observed, though thousands of specimens were regularly examined at different seasons of the year over a period of six years.

The type observed by Willey is certainly more advanced than the one recorded by Southwell, even though the two have previously not been distinguished from one another.

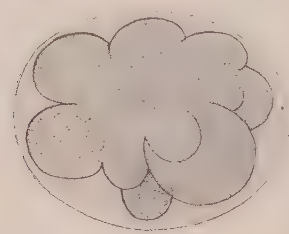
As nothing is known regarding the mode of origin of these daughter endogens from the parent cyst we are unable to say anything regarding the relation of these forms with those described in Group A. The endogens may arise either as proliferations from the epithelial lining of the mother larval form, in which it would be similar to what occurs in Monocercus. On the other hand the daughter endogens may arise from the internal intima filling up the cavity of the mother larva. In that event, this method of endogenous budding would be quite

different from the other forms. It cannot, in any case, be parthenogenetic, as no eggs or egg-like structures are shown in the figures or described in the minute account of the anatomy of the larval form given by Herdman and Hornell (1906).

TYPE C.—WITH EXTERNAL BUDDING

In the following cases, budding takes place by proliferation from the external surface.

a. Polycercus.—A species of the genus Polycercus was found by Haswell and Hill (1894) in the earthworm *Didymogaster sylvatica* Fletcher. This species of Polycercus differed from the other species of this genus in having a definite type of development which consists of a process of external proliferation from the product of the hooked embryo in the following manner. "The hooked embryo in Polycercus develops into a rounded cellular body, which becomes enclosed in a cyst, probably entirely of an adventitious character. Buds are given



8

9

Fig. 8.—Cyst of *Polycercus* sp. (After Haswell and Hill.)
Fig. 9.—Cyst of *Staphylocystis glomeridis*. (From Benham.)

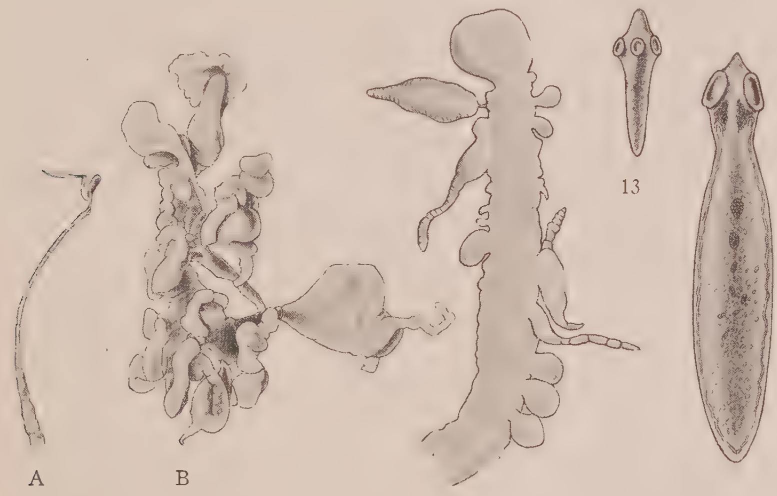
off from the periphery of the mass and develop into cysticercoids, which soon become free in the interior of the cyst (Fig. 8). The head, with its hooks and suckers is developed from the central portion of the solid body, the middle layers form the 'body' and the outermost, the caudal vesicle" (Haswell and Hill, 1894).

b. Staphylocystis. In the species *Staphylocystis glomeridis* Villot another type of asexual reproduction is to be met with. Here by the successive branching and external proliferation of secondary cysticercoids a complex organism is produced (Fig. 9). This type of external gemmation differs from that in Polycercus described above in that there is no external cyst wall in Staphylocystis, but as the cyst in Polycercus is considered by Haswell and Hill to be only an adventitious investment, the two may be considered to be nearly related.

c. Sparganum. In *Sparganum* (*Pleurocercus*) *proliferum* Ijima (1905), found in the skin of a Japanese woman, there is a definite

kind of budding from the external surface of the larval bothriocephalid. In this case buds are given off from the parent stock in a more or less irregular manner (Fig. 10). The buds are direct outgrowths from the body of the larvae and later on they become detached. As many as seven larvae were found in the same cyst and were considered to be the detached buds.

d. Urocystidium. Beddard (1912), in examining parasites from *Fiber zibethicus,* found two tapeworms. These were considered by him to be the sexual and asexual phases of a new tapeworm. He



A B 10 11 12 13

Fig. 10.—(*a*) A single individual of *Sparganum proliferum.* (After Ijima.) (*b*) A budding individual of *Sparganum proliferum.* (After Stiles.)

Fig. 11.—Asexual budding individual of *Urocystidium gemmiparum.* (After Beddard.)

Fig. 12.—An adult specimen of *Ilishia parthenogenetica* removed from the cyst. (Original.)

Fig. 13.—A young specimen of *Ilishia parthenogenetica* from the mesentery of Hilsa fish. (Original.)

regarded them as the type of a new genus which he named Urocystidium, the asexual form of which like Sparganum just referred to, buds off laterally and irregularly a series of young forms resembling the parent asexual form (Fig. 11). Beddard, however, considered his form differed from Ijima's type in that the buds were segmented. This does not appear to be an important difference, because Beddard's asexual worm is also segmented, whilst Ijima's *Sparganum proliferum* is unsegmented, and also the buds arising therefrom.

The above three types of external proliferation seem to be quite distinct from the various other types described in which buds arise from the inner walls of a cysticercoid.

TYPE D.—WITH PARTHENOGENETIC REPRODUCTION

We may now consider a method of parthenogenetic reproduction, which, as far as we are aware, is unique amongst the Cestoda and is only paralleled by what occurs in certain larval trematodes.

Ilishia parthenogenetica Southwell and Prashad, 1917.

This curious parasite was found in Bengal, India, heavily infecting the mesentery and liver of *Hilsa ilisha* (Ham. Buch), the Indian shad. In this case the worm is an adult, and so the parthenogenetic method of reproduction to be described, differs from all the preceding cases, which, as we have already noted, occur only in larval forms.

In this case definite egg-cells practically fill up the whole of the worm (Fig. 12). These eggs develop parthenogenetically into young forms which resemble the adult in all respects except size. After the worms (Fig. 13) have developed to the stage described above, the young forms find their way out of the parent form, become adult, and repeat the same life-history.

We do not propose considering here the metameric repetition of the proglottides in ordinary adult tapeworms, which by some authors is considered to be a type of budding. It will be obvious from the above facts that the methods of reproduction described are designed to ensure a very large infection for the propagation and preservation of the species — a very doubtful matter with animals having so complicated and uncertain a life-history as the forms described above. We are also of opinion that, up till now, too much attention has been paid to recording and describing new species of tapeworms, whilst in the vast majority of cases the life-histories have been utterly neglected. We are aware of the difficulty attending the elucidation of these life-histories, but it appears to us that labor in this direction would not go unrewarded and in all probability would result in the discovery of still other forms of reproduction and give results worthy of the labor and time. The field is wide and unexplored.

SUMMARY

In the above account we have discussed the followed methods of asexual and parthenogenetic reproduction amongst the Cestodes.

(1). Internal proliferation from the wall of the cysticercoïd, as seen in Polycercus, Coenurus and others.

(2). Endogenous budding, as seen in Willey's Merocercus.

(3). External budding, as exemplified in Haswell and Hill's species of Polycercus, Staphylocystis, etc.

(4). Parthenogenetic reproduction in *Ilishia parthenogenetica,* an adult tapeworm of doubtful affinities.

References Cited

Beddard, F. E. 1912. On an asexual tapeworm from the Rodent *Fiber zibethicus,* showing a new form of Propagation, and on the supposed Sexual Form. Proc. Zool. Soc., London, 1912: 822-850.

Haswell, W. A. and Hill, J. P. 1894. On Polycercus: a proliferating cystic parasite of the earthworms. Proc. Linn. Soc., N. So. Wales, (2) 8: 365-376; 2 pl.

Herdman, W. A. and Hornell, J. 1906. Pearl production. Ceylon Pearl Oyster Reports, Vol. V, Royal Society, London.

Hornell, J. 1906. Report on the *Placuna placenta* Pearl Fishery of Lake Tampalakaman. Rept. Ceylon Marine Biol. Lab., 1: 41-54.

Ijima, I. 1905. On a new Cestode larva parasitic in Man. Jour. Coll. Sci., Japan, 20: 1-21.

Southwell, T. 1910. A note on endogenous reproduction discovered in the larvae of *Tetrarhynchus unionifactor* inhabiting the tissues of the Pearl Oyster. Ceylon Marine Biol. Repts., Vol. I.

Southwell, T. and Prashad, B. 1917. Cestode Parasites of Hilsa, *Hilsa ilisha* (Ham. Buch.). Bengal Fishery Bull., No. 2.

Willey, A. 1907. Report on the Window-Pane Oysters (*Placuna placenta,* "Muttuchchippi") in the Backwaters of the Eastern Province. Spolia Zeylanica, 5: 33-57; 1 pl.

THE EXCRETORY SYSTEM OF *AGAMODISTOMUM MARCIANAE* (LA RUE), THE AGAMODISTOME STAGE OF A FORKED-TAILED CERCARIA *

William Walter Cort
University of California

In a recent paper La Rue (1917) described as *Cercaria marcianae* a new larval trematode from *Thamnophis marciana* (Baird and Girard). Since this form is in the agamodistome stage, the species should be referred to the provisional genus Agamodistomum Stossish and the name changed to *Agamodistomum marcianae*. In the summer of 1915 I collected material of this same species from the tissues and lymph spaces of tadpoles of *Rana pipiens* and *Rana clamitans,* and from the digestive tract and body cavity of the garter-snake, *Thamnophis sertalis,* from the region of Douglas Lake, Michigan. It was found possible to introduce these larvae into the snakes by feeding them with infected tadpoles, but no advance in development followed, and the larvae soon made their way out from the intestine into the body cavity and tissues. This observation and La Rue's description of *Agamodistomum marcianae* from a snake show that this species has two secondary intermediate hosts. Since tadpoles formed a very large part of the food of the garter-snakes examined, it seems very probable as suggested by La Rue (1917:8) that the snakes obtain their infection from this source. This makes a very unusual complication in the life-history of this trematode involving a change of host without an advance in development. I have also found *Agamodistomum marcianae* in lymph spaces under the skin of adults of *Rana pipiens* from North Judson, Indiana.

The host in which *Agamodistomum marcianae* completes its development is not known. Also its structure at this stage gives little clue to the systematic position of the adult. The character of its cephalic glands and excretory system, however, indicates that it has developed from a forked-tailed cercaria, and a comparison of its structure with that of *Cercaria emarginatae* Cort and *Cercaria douglasi* Cort (see Cort, 1917) shows such close correspondence in the structure of the digestive and excretory systems and in the characteristics of the spination, suckers and cephalic glands that a very close relationship is established. Differences from *Cercaria emarginatae* in the number of cephalic glands and from *Cercaria douglasi* in the structure of the excretory bladder makes it impossible to connect *Agamodistomum marcianae* with either of these species. I should expect, however, to find the cercaria of this species to be very much like these two cercariae.

* Publication No. 41 from the University of Michigan Biological Station.

Except for the arrangement of the cuticular spines my studies on *Agamodistomum marcinae* agree with La Rue's description. I am able to add to his account a complete analysis of the excretory system, made from the study of large numbers of living specimens. The excretory system of this species is of especial significance since it gives an idea of the development of the type of excretory system found among the forked-tailed cercariae.

La Rue's (1917: 4) account of the arrangement of the cuticular spines in *Agamodistomum marcianae* is as follows: "The surface of the body is covered with minute spines arranged in regular longitudinal rows. The spines at the anterior end of the body are a trifle longer

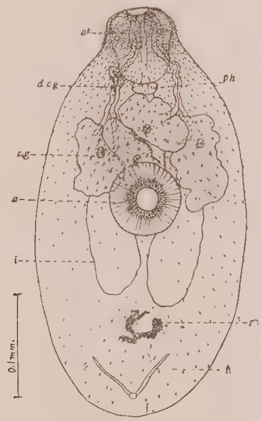


Fig. 1.—Camera lucida drawing of *Agamodistomum marcianae* (La Rue), ventral view; *os*, oral sucker; *ph*, pharynx; *a*. acetabulum; *dcg*, ducts of cephalic glands; *cg*, cephalic glands; *i*, intestinal cecum; *b*, excretory bladder; *r*, primordia of reproductive organs.

than elsewhere." My studies on the arrangement of the spines in living specimens of this species and from toto mounts of my own material and of material sent me by La Rue make necessary a revision of his account. The ventral surface is completely covered with spines which are very thickly set over the anterior tip and somewhat scattered in the postacetabular region. The margin of the acetabulum is armed with two to three rows of closely set spines pointing in, which are so placed that they add greatly to the gripping power of the sucker. The dorsal surface has the same distribution of the spines as the ventral to the region of the bifurcation of the intestinal caeca, but back of this level the cuticula is smooth except for a few scattered spines near the posterior tip. Figure 1 shows the distribution of spines on the ventral surface of *Agamodistomum marcianae*.

In the description of the excretory system of *Cercaria marcianae* the names of the subdivisions as used by Looss (1894: 156) will be employed. This writer divides the trematode excretory system into four main subdivisions which he considers to be natural and recognizable in all forms. They are (1) the excretory vesicle or bladder; (2) the collecting tubes; (3) the capillaries, and (4) the flame cells. The bladder is the region next to the excretory pore, and is the only part of the system which has a definite cellular lining and muscle layers. The collecting tubes connect the bladder with the capillaries. The collecting tubes which flow directly into the bladder, which for convenience may be called the main collecting tubes, are often divided

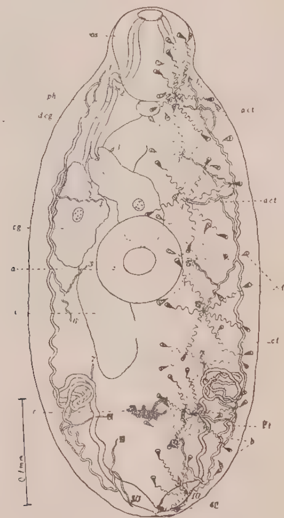


Fig. 2.—Excretory system of *Agamodistomum marcianae* (La Rue), ventral view. On the right side of the figure all parts of the excretory system are shown, but on the left side the capillaries and flame cells are omitted. The numbers 1 to 10 on each side indicate the points where the accessory collecting tubes are joined by the capillaries; letters as before; also, *act*, accessory collecting tubes; *f*, flame cells; *ct*, main collecting tubes; *e*, excretory pore.

and subdivided, a reduction in caliber following division. For convenience also the collecting tubes are divided by Looss into the principal collecting tubes and the accessory collecting tubes. The latter include those which are directly connected with capillary groups. The capillaries are the tubules from the flame cells, and are usually arranged in groups of a definite number.

Figure 2 shows the excretory system of *Agamodistomum marcianae*. On the right side of the figure all parts of the system are shown, while on the left side the flame cells and their capillaries are omitted. The numbers 1 to 10 on each side indicate the points where the accessory collecting tubes are joined by the groups of capillaries.

The excretory pore (*e p*) is at the posterior end slightly dorsad in position and forms the only point of union of the lateral halves of the system. The bladder (*b*) is V-shaped, the sides extending about half way up to the acetabulum, where they form complicated coils. Near the pore the bladder on each side is dilated for a short distance. It is in these dilated portions that the contraction and expansion having to do with the expulsion of fluid is most noticable. Each side of the bladder receives an anterior and posterior main collecting tube (ct). Each anterior main collecting tube receives three branches each of which is divided into two accessory collecting tubes (*act*), while each posterior main collecting tube receives two branches each of which is divided into two accessory collecting tubes. This makes a total of five pairs of accessory collecting tubes on each side (numbers 1 to 10). Each of these accessory collecting tubes receives the capillaries from six flame cells. One accessory collecting tube of each pair with its group of capillaries is dorsal in position and the other is ventral. In

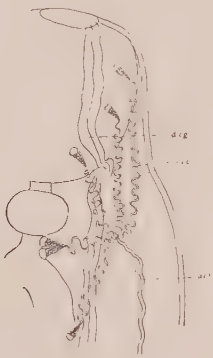


Fig. 3.—Group of flame cells and capillaries at the anterior end of *Agamodistomum marcianae* (La Rue), showing a flame cell in the process of longitudinal fission; letters as before.

Figure 2 the capillaries and flame cells of the dorsal side are shown with dotted lines. There is then a total of one-hundred and twenty flame cells, connected by their capillaries in groups of six with ten pairs of accessory collecting tubes. The only variation from the pattern just described was found in the capillary group shown in Figure 3, in which one of the accessory collecting tubes of the anterior end is joined by only five capillaries. At the end of one of these capillaries was a flame cell apparently in the process of longitudinal fission. This observation is suggestive of a possible method of formation of capillary groups. Altho I searched carefully for further evidence on this point no other instances of such division were found.

The comparison of the excretory system of *Agamodistomum marcianae* with that of the closely related forked-tailed cercaria *Cercaria emarginatae* (Cort, 1917, Fig. 2 B), gives an idea of the method of

development of this type of excretory system. The general pattern of the two systems is the same, but the subdivisions are much more complicated in the agamodistome. The divisions of the main collecting tubes correspond in number and position in both forms. In *Cercaria emarginatae* these ten subdivisions end in flame cells and are therefore equivalent to capillaries, while in *Agamodistomum marcianae* with increased body size there is need of an increased number of flame-cells, and the ten divisions of the main collecting tubes are bifurcated into twenty accessory collecting tubes, each receiving the capillaries from six flame-cells. Since *Agamodistomum marcianae* does not belong to the same species as *Cercaria emarginatae* it cannot be argued that its excretory system is necessarily derived from one exactly like that of this cercaria. Yet the structural agreement between these two species indicates such close relationship and the homologies of their excretory systems are so striking, that when the conservativeness of the trematode excretory system is considered, it seems certain that the above comparison shows in a general way what is to be expected in the development of the type of excretory system of the forked-tailed cercariae. It is interesting to note that these observations agree in with the theory of Looss (1894; 248-251) as to the method of development of the trematode excretory system. However, the total available data on the whole subject of the development of the trematode excretory system is so limited that any adequate attempt to establish general principles must await an increase in knowledge.

SUMMARY

1. The larval trematode described by La Rue from *Thamnophis marcaiana* as *Cercaria marcianae* should be named *Agamodistomum marcianae*.

2. The excretory system of this species is very complicated consisting of sixty flame cells on each side arranged in a very definite pattern.

3. The finding of a flame cell in one of the groups dividing by longitudinal fission suggests that the capillary groups may be formed by such divisions.

4. *Agamodistomum marcianae* is the agamodistome stage of a forked-tailed cercaria, and its excretory system gives an idea of the development of the excretory system in this group.

References Cited

Cort, W. W. 1917. The Homologies of the Excretory System of the Forked-tailed Cercariae. Preliminary Report. Jour. of Parasit., 4: 49-57.

La Rue, G. R. 1917. Two Larval Trematodes from *Thamnophis marciana* and *Thamnophis eques*. Occasional Papers of the Museum of Zoology, University of Michigan, No. 35; 12 pp.

Looss, A. 1894. Die Distomen unserer Fische and Frösche. Biblioth. Zool., No. 16; 226 pp., 9 pls.

NATURAL OCCURRENCE OF EOSINOPHILIAS

S. Hadwen

When the juices obtained from Hypoderma larvae, either diluted or otherwise, are injected under the skin of a susceptible animal, the first effect noticed will be local. At the point of injection a blister-like spot will be seen, and a necrotic area will occur. In twenty minutes to half an hour, swelling will be noted. The necrotic spot in the center will be depressed. Smears made from the swelling some hours later, reveal the presence of an eosinophilia, and if the material which was injected contained bacteria, phagocytosis by the eosinophils. This observation of phagocytosis by the eosinophils was made by myself and certified by Dr. B. H. Ransom at Washington, D. C. The reason for the eosinophils assuming the rôle which is usually assigned to the neutrophils, is apparently because the bacteria are rendered attractive by their being bathed in the verminous juices. These cells containing bacteria are not numerous, and were only found in a few cases. According to Weinberg and Séguin (1914, 1915), in their reports on the experimental injections of the juices of *Ascaris* and other intestinal parasites, the principal function of the eosinophils is to neutralize toxins, but they also ingest small particles of débris or bacteria when they are present in verminous fluids. They were also successful with mixtures in vitro. These findings seem to indicate that the eosinophils play a very important rôle in picking up the bacteria which are introduced into the body by the bites of intestinal parasites, and in neutralizing toxins which may be absorbed. The swelling which follows these injections may persist for several days. The same effect may be produced by puncturing or crushing a warble larva "in situ" under the skin. The liberation of the proteins contained in the grub causes a local swelling, anaphylactic in type and stimulate an eosinophilia. When a smear is made from the contents of the swelling, large numbers of eosinophils are seen and innumerable granules. Proof that the eosinophils are attracted by the secretions and excretions of warble larvae alone and not by bacteria, can be found by examining the fluids in the edemas surrounding them in the gullet. Here the larvae are usually sterile as I have proved by examining numerous slides, also by extracting the grubs and incubating them in bouillon. Three out of four grubs thus extracted proved to be sterile. Further, the grubs which were found in the neutral canal in a

Presented before the Helminthological Society of Washington Nov. 30, 1917.

number of other animals (7 in one case) must also have been sterile, as only small edematous tracks and gray areas in the fat were noted. In the gullet the eosinophil was the principal cell encountered. There were only a few neutrophils and a smaller percentage of mononuclears and macrophages. Pus was taken from the cavities beneath the skin of cattle in which warble larvae were living. Eighteen cows were examined and in only two instances did I find bacteria in large numbers. In one of these, it was only after a prolonged search that an eosinophil was found. In the other, only an occasional one. In the sixteen other smears eosinophils were plentiful and bacteria correspondingly scarce. Differential counts were attempted, but of course, only give a rough idea of the percentage owing to the degenerated condition of many of the cells. In one case the neutrophils were 75%, the mononuclears 12.5%, the eosinophils 7.5% and the macrophage cells 4.4%. On the same date the blood taken from the general circulation showed neutrophils 25.75%, the mononuclears 68% and the eosinophils 6.25%.

No doubt the large percentage of the neutrophilic leukocytes in the pus smears was due in part to the presence of bacteria, as in the swellings of the gullet they were only found in small numbers.

The percentage of the eosinophils in many of the other cases was not as high as in the example given and in one of them it was as low as 2%. If, however, there had been no bacteria with which to contend, it is probable that the percentage would have been higher owing to the presence of fewer neutrophils.

Another experiment might be cited to prove that the eosinophile cell is *par excellence* the agent which truly repels and neutralizes verminous products. A few drops of warble juice were instilled into a steer's eye at 10 a. m., and at 7:30 p. m. smears were made from the discharge. The cells were practically all eosinophils.

These experiments are a continuation of the work recorded by E. A. Bruce and myself in 1916, relating to the injection of juices derived from oestrid larvae, and of later experiments made in collaboration with Dr. B. H. Ransom at Washington, D. C. Nearly all the publications to which I have had access, discussing injections of verminous juices, have reference to those inhabiting the intestines, and though the fluids from the parasites may have been rendered sterile by filtration, their proteins may have become mixed during the process of absorption or ingestion of the intestinal contents by the parasites (the hydatid cyst fluids excepted). *Hypoderma* larvae are very suitable for such experiments, seeing that they are sterile until they bore through the skin, and they nourish themselves solely on animal tissues. It is a well-known fact that, as a rule, in verminous anemias the percentage of eosinophils is high, but in some instances they may be very scarce. Weinberg and Séguin noted this in their experiments and suggest that the few eosinophils which were in the

circulation had been attracted to the parts affected in order to repel a verminous invasion.

Experiments are contemplated to determine what curative effects the injection of worm juices may have on such cases.

I am indebted to Dr. Ransom for sending me two important papers recently, by Marchesini and Barnett which bear on this subject.

References Cited

Weinberg, M. and Séguin, P. 1914. Recherches biologiques sur l'éosinophilie (1er mémoire). Planches XV et XVI.

Weinberg, M. and Séguin, P. 1915. Recherches biologiques sur l'éosinophilie (2e partie). Propriétes phagocytaires et absorption de produits vermineux. Planches VI et VII.

THREE UNUSUAL CASES OF PARASITISM (A SLUG, A MYRIAPOD, AND COCKROACHES) REPORTED IN MAN

C. W. Stiles
Professor of Zoology, U. S. Public Health Service

Cases of pseudoparasitism and of spurious parasitism occasionally come to the attention of medical zoologists. Some of these are reduced to errors in observation, some to the chance presence of an organism in a host, some to attempts on the part of hysterical patients to mystify their physicians.

The three following cases are rather unusual and are published on this account.

Spurious parasitism due to a slug (*Limax flava*). Specimen 11, 165. A slug, determined by Dr. Paul Bartsch as *Limax flava,* was sent to the Hygienic Laboratory by the Maryland State Department of Health with the report that it was alleged to have been passed from the bowels by a patient in Baltimore.

As it is in good state of preservation it is difficult to assume that it passed through the intestinal canal.

A geophilid myriapod from stomach. No. 11, 159. Mr. L. M. McCormack of Ashville, N. C., has recently sent in a myriapod with the following history:

"I am sending you a specimen which the physician who brought it into the laboratory declares was in the stomach contents, brought up by a stomach pump; it looks to me like an adventurer and not an intestinal parasite."

Dr. L. O. Howard has determined this organism as a geophilid.

Several cases of the presence or alleged presence of myriapods in man have been recorded and in most instances the organisms have been geophilids. In some cases they were reported from the nasal passages, and associated with severe headache, in others they were reported from the intestine. R. Blanchard has summarized cases recorded by Littre (1708), Kerckring (1717), Sandifort (1789), Blumenbach (1807), Scoutetten (1827), Lefèvre (1833), Laboulbène (1867), Le Roy (1878), and Giard (1880).

Croton bugs (*Blatella germanica*) said to have come from an abscess of the jaw. Specimen 11, 226. This specimen was forwarded by Dr. Harold N. Cole of Cleveland, Ohio, with the following information:

Patient, a luetic in the City Hospital, had a large horse-chestnut sized swelling under angle of left jaw; the lesion has been very tender and the glands posterior to this are swollen and tender and scars of other glands are also seen under the jaw. On Nov. 21, 1916, patient suddenly had a chill with a temperature of 103 and began to expectorate a bloody sputum; upon examination of this expectoration a capsule was found together with some small arthropods. "Of course we cannot be absolutely sure, but apparently the patient expectorated these organisms."

The organisms in question were determined by A. N. Caudell of the U. S. Bureau of Entomology, as young cockroaches; the capsule was probably the egg case of the cockroach.

NOTES

Dr. C. A. Kofoid, Consulting Biologist for the California State Board of Health, in the Bureau of Communicable Diseases, has been granted leave of absence for war work. Dr. W. W. Cort has become acting Consulting Biologist in charge of the Biological Division during Professor Kofoid's absence.

The Severance Union Medical College at Seoul, Korea, which was established as a special school on May 14, 1917, includes in its plan of organization a Research Department under the direction of Dr. Ralph G. Mills. Prominent among its aims as listed in the report of the director stands, "To investigate botanical and zoological problems, especially those that bear upon the questions of animal parasites and native drugs."

The National Research Council has asked the persons named below to serve as a committee on medical zoology which will be related on the one hand to its work in zoology and on the other hand and more especially to its work on medicine:

ENTOMOLOGY

Dr. L. O. Howard, Department of Agriculture, Washington, D. C. (chairman of group); Prof. Charles T. Brues, Bussey Institute, Forest Hill, Mass.; Prof. C. V. Riley, Cornell University, Ithaca.

PROTOZOOLOGY

Prof. (Major, S. C. N. A.) C. A. Kofoid, University of California, Berkeley, Calif. (chairman of group) (Fort Sam Houston, Texas); Dr. Theobald Smith, Rockefeller Institute, Princeton, N. J.; Prof. F. G. Novy, University of Michigan, Ann Arbor.

HELMINTHOLOGY

Prof. Henry B. Ward, University of Illinois, Urbana (chairman); Dr. C. W. Stiles, U. S. Public Health Service, Washington; Dr. Allen J. Smith, University of Pennsylvania, Philadelphia.

The war organization of the National Research Council includes a division on Medicine and related sciences of which Dr. Richard M. Pearce, a member of the Council, is chairman. The committee on medical zoology is a section of this division.

BOOK REVIEWS

THE CLINICAL PATHOLOGY OF THE BLOOD OF DOMESTICATED ANIMALS. Samuel Howard Burnett, A.B.M. M.S., D.V.M. Professor in Comparative Pathology, New York State Veterinary College, Cornell University, Ithaca, New York. The Macmillan Company, 1917. xvi + 166 pages. 4 plates, 23 figures. $2.25.

The author has attempted to do for students and workers in the veterinary field what numerous other works have done for the human subject. This treatise, which is a pioneer in its field, has undergone considerable change in this, the second edition. As a text for college work it fills a conspicuous need of undoubted value and deserves commendation.

Two chapters deal with topics of especial interest to students of animal parasites. In Chapter IX, Infectious Diseases Due to Protozoa, the author discusses spirochetosis, Texas fever, various forms of piroplasmosis and of trypanosomatosis. In each case the problem of changes in the blood is carefully analyzed and interpreted in so far as their significance can be determined.

The last chapter, Chapter XI, Diseases Due to Animal Parasites, deals with the metazoan parasites alone. It seems unduly brief and has hardly received attention commensurate with its importance or proportionate to the general plan of the book. It must be confessed that in this respect the author merely follows the habits of most workers on human hematology. The topic is deserving of more extended treatment in a later edition.

Under the heading of Hookworm Campaigns the *Tropical Diseases Bulletin* for February 14 (vol. 11, p. 100-112) presents an extremely valuable summary of operations which were originally reported in scattered and often inaccessible publications. Reviews of this character call for special comment even though all the work done by the *Bulletin* has been organized in most effective fashion and deserves the highest praise from scientific workers at home and abroad.

Explanation of Plate

Figs. 1-5.—Spores of *Nosema bombycis* with extruded polar filament after subjection to the action of perhydrol.

Fig. 6.—A spore of *Myxosoma funduli* treated in the same way.